ENERGY CONSUMPTION GUIDE 75

Energy use in Ministry of Defence establishments

This Guide will assist those personnel responsible for energy consumption in MoD buildings and sites to:

- assess energy performance against benchmark data for MoD buildings and sites
- assess the true scope for energy reduction and achievement of a defined standard of performance
- identify buildings for priority attention
- achieve reduction in fuel usage and carbon emissions
- reduce impact on the environment
- achieve Government fuel reduction targets

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ENERGY EFFICIENCY

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ENERGY CONSUMPTION GUIDE 75

This Guide is published as part of the Department of the Environment, Transport and the Regions' (DETR's) Energy Efficiency Best Practice programme. The programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events.

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Energy use in Ministry of Defence establishments

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This Guide has been produced for Ministry of Defence (MoD) establishments to enable all involved at a national and local level to assess energy performance of MoD sites quickly and effectively. It has been introduced in response to the action plan generated from the National Audit Office and Public Accounts Committee reports into Management of Utilities in the MoD. This assessment will help to identify the buildings with the most potential for savings and give guidance for priority actions.

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INTRODUCTION 1

Purpose

This Guide has been produced for Ministry of Defence (MoD) establishments to enable all involved at a national and local level to assess energy performance of MoD sites quickly and effectively. This assessment will help to identify the buildings with the most potential for savings and give guidance for priority actions.

Who is the Guide for?

This Guide is for professional energy managers within the MoD, and Commanding Officers and Heads of Establishments, irrespective of their background or experience. While this Guide has been prepared for UK sites, it can be successfully applied to overseas establishments. However, users should recognise the need to apply local degree day data (see appendix 1).

How much does the MoD spend on energy?

The pie charts in figure 1.1 show the annual energy consumption and costs for the MoD worldwide. Electricity represents 24.5% of total consumption but represents 56.3% of total costs. This reflects the fact that electricity is four times more expensive than fossil fuel per kWh. Therefore, savings in electricity usage bring relatively larger cost and carbon dioxide (CO_2) savings, and should be targeted early in any energy management programme.

The benefits of energy management

- Saving energy results in less environmental pollution from CO_2, acid rain and particulates.
- Saving energy will help to meet UK Government energy/CO_2 reduction targets.
- Saving energy saves money which can be used for other needs.
- Good energy management practices often result in more comfortable working conditions, so that people are neither too hot nor too cold.
- Good energy management often results in lower maintenance costs, reduced plant downtime, improved reliability and longer plant life.
- Saving energy is a demonstration of good overall management of a site.

The MoD estate

MoD establishments are often diverse and complex sites. The occupancy patterns of some types of buildings are variable (eg tours of duty). Energy is often used for specialist facilities (eg security/runway lights) and frequently some type of district heating system is used.

Many buildings are conventional (eg offices, hangars and warehouses) but some require special internal conditions (eg set humidity levels in ammunition stores), and some buildings fall into special categories (eg simulators or satellite communications).

The aim of this Guide

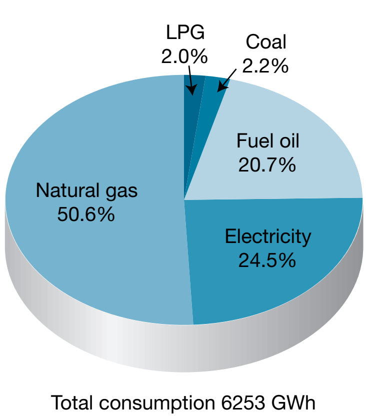
This Guide:

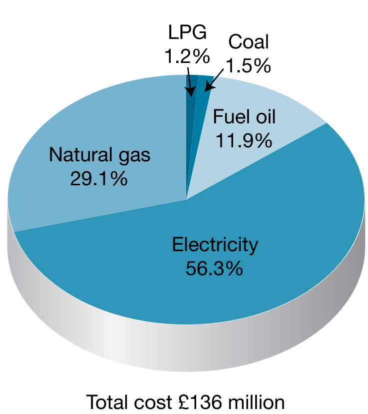
- provides comparisons of energy use within specific buildings and usage sectors, and sets consumption benchmarks based on known good practice
- provides a method to quickly identify consumption performance for buildings/sites and identify areas for attention
- promotes the benefits of energy efficiency and provides practical advice on improving performance in MoD establishments.

What are benchmarks?

Building energy benchmarks provide representative values for common building types against which a building's performance can be compared. Comparisons with simple benchmarks of annual energy use per square metre of floor area ($kWh/m^2/annum$) will allow the standard of energy efficiency to be assessed and identify priority areas for action.

Figure 1.1 Total non-operational energy consumption and costs for the Royal Navy, Army and RAF worldwide (1997/98)





INTRODUCTION

A summary of the benchmarks is shown in appendix 3. This is printed on a page that folds out from the last page of the Guide, so that the benchmarks may be referred to while reading other sections of the Guide.

Although rounded for clarity, the benchmarks presented in this Guide are largely derived from information obtained from within the MoD estate.

Achievement of the benchmark figures reflects good practice – nothing more. There is no room for complacency. Therefore the achievement of benchmark levels should be the minimum acceptable performance to any Commanding Officer or Head of Establishment.

Why benchmarks are important

It is important to supplement energy reduction targets expressed in overall percentage terms with benchmarking on individual building types and sites.

An overall percentage reduction in energy can be misleading for a number of reasons.

- Past performance may have been particularly poor so that a percentage improvement might appear good but gives no indication of actual performance. In the past, blanket percentage improvement targets have often been made across estates. Sites which have performed poorly in the past find it easy to achieve the set target, and sites that have performed well find it difficult. Benchmarks reverse this and rightly so. They are fair for all.
- Target percentage savings could be achieved by rationalising the use of a building or the size of site without any attempt to improve energy efficiency. Therefore, a percentage improvement is no indication that either a building or a site is performing well.
- Percentage improvement targets look backwards at past performance but give no indication of either absolute performance for a particular building type or the potential for future savings.

In contrast, benchmarking is a useful tool because:

- actual performance can be measured against standards of good practice
- future energy-saving potential can be assessed
- effort can be targeted on areas of need
- over-investment can be avoided in buildings already performing well
- buildings on the same site can be compared
- similar buildings on different sites can be compared
- sensible and appropriate targets can be set for each site.

Benchmarking is not intended to be a precise science. However, benchmarks are useful in indicating approximate performance levels so that buildings can be compared, and areas of opportunity can be quickly identified.

An important use of benchmarking is the comparison of building or site performance to benchmarks on an annual basis. This will identify good or poor energy performance trends over a period of time.

In order to use benchmarks it is important to categorise buildings into different types. For the purpose of this Guide the following building types have been selected:

- offices
- sports and recreational facilities
- multi occupancy accommodation
- workshops
- motor transport facilities
- stores/warehouses
- hangars
- messes with integral accommodation
- training and education facilities
- catering facilities
- specialist site facilities.

INTRODUCTION

Using benchmarks

If a building is submetered, the benchmarks for each building type can be used to make a direct comparison (see sections 3 to 12).

Some buildings may have submetering for electricity but not for fossil fuel or vice versa. In these situations only one of the two benchmark figures can be used.

If a building is not submetered for use of fossil fuel or electricity, it may be possible to install submetering or temporary metering.

If a site has very little or no submetering, the benchmarks can still be used to build up a composite picture of the site to give an overall estimate of site consumption. This can then be compared with actual consumption to give an indication of overall site performance. This methodology is described in section 14.

Energy and the environment

The burning of fossil fuels produces gases harmful to our environment. These gases include sulphur dioxide and oxides of nitrogen, which contribute to acid rain, and CO_2, which contributes to global warming and climate change.

At a local level, a build up of pollutants reduces air quality and is harmful to human health.

The figures in table 1.1 show the mass of carbon and the volume of CO_2 released into the atmosphere as a result of consuming a kWh of each fuel.

Fuel	kg of carbon per kWh	m^3 of CO_2 per kWh
Electricity	0.127	0.254
Gas	0.055	0.103
Fuel oil	0.079	0.147
Solid fuel	0.093	0.174

Table 1.1 Carbon emissions for energy use

HOW TO CALCULATE ENERGY PERFORMANCE OF BUILDINGS

2

To make use of benchmarks it is important to adjust raw energy consumption data to the same basis as the benchmarks in order to make a like-for-like comparison. There are nine major steps.

Step 1

Convert energy units to kWh

Electricity is already measured in kWh but other types of fuel must be converted to kWh so that a common energy unit is used. Conversion factors from table 2.1 can be used.

Fuel	Measured units	To get to kWh, multiply by
Electricity	kWh	1.0
Natural gas	m^3 kWh 100 ft^3	10.7 1.0 30.3
Gas oil (35 sec)	litres	10.6
Light fuel oil (290 sec)	litres	11.2
Medium fuel oil (950 sec)	litres	11.3
Heavy fuel oil (3500 sec)	litres	11.4
LPG/propane	tonnes	13 780
Coal	kg	9.0

Table 2.1 Fuel conversion factors

Step 2

Adjustment in energy consumption for buildings heated electrically or from remote boilers

The fossil-fuel benchmarks assume the heat and hot water is supplied from a boiler located in the building under consideration. Therefore the flue-gas heat losses and other heat losses are included in the benchmarks.

However, if heat is supplied electrically or from a remote boiler (eg via a district heating system) it is important to adjust consumption so that a like-for-like comparison is made with the benchmarks.

If the heat supply is monitored by a heat meter, the readings will need to be divided by 0.76, or an appropriate figure to take account of flue-gas and other heat losses (see worked examples in sections 3 and 7). Distribution losses between the boiler and the heat meter are not included in the calculation at this stage as these losses are not relevant to an individual building's energy performance. These losses are considered separately in sections 13, 14 and 15.

Where a remote boiler feeds two or more buildings which are not fitted with individual heat meters, the procedure in section 14 should be followed.

If a building is electrically heated, it is important to separate space heating/hot water electricity usage from that for general power requirements. Again, the electricity consumption for space heating/hot water should be divided by 0.76 (or an appropriate figure) so that an estimate can be made of how much energy would have been required using fossil fuel in a boiler plant. This will allow a like-for-like comparison to be made with benchmark performance.

HOW TO CALCULATE ENERGY PERFORMANCE OF BUILDINGS

Step 3

Estimate the energy used for space heating

Where central plant provides both space heating and hot water services, it is important to determine the proportions of each.

If space-heating energy is not metered separately from hot water, it is possible to gain a good estimate of the split by determining hot water use in July or August when no space heating is required. Alternatively, some of the typical end-use energy tables for each building category give a division between heat and hot water that can be used.

Step 4

Adjust the space-heating energy to account for the weather

When the weather is severe a building will use more energy. In order that a reasonable comparison can be made with data from different years, a correction factor is applied. There is an outside temperature called the base temperature (taken to be 15.5°C for most buildings), above which heating is not necessary because of internal heat gains from people, equipment, lights and solar gain. The space-heating requirement is dependent on the number of 'degree days'.

As an example, if for one week the average outside air temperature was 12.5°C, this would represent a heating requirement for the building of $(15.5 - 12.5) \times 7 = 21$ degree days. For a more detailed explanation of degree days see appendix 1.

In order to calculate the weather correction factor, the total degree days for a standard year are divided by the degree days for the year in which the energy data is to be considered. The standard year is taken to have characteristics that are typical of the last 20 years' average for the UK and this totals 2462 degree days.

$$\text{Weather correction factor} = \frac{\text{Standard degree days (2462)}}{\text{Degree days for energy data year}}$$

All the benchmark figures in this Guide have been calculated from MoD sites throughout the UK. To obtain a standard benchmark they have all been adjusted to standard degree days. For this reason, it is important to weather-correct the space-heating element of energy consumed so that calculated performance for any site in kWh/m^2/annum is compared with the benchmark on a like-for-like basis.

Monthly degree days are published by the DETR for standard regions of the UK. Degree day values, appropriate to specific sites, can be collected by data loggers and fed directly into a personal computer (PC). Variation in degree days only affects the space-heating component of the fossil-fuel consumption and not the water-heating component. It is for this reason that the two components must be separated.

Weather correction should also be applied to any electrical energy used in space heating.

Step 5

Modify the space-heating energy to account for exposure

Part of the heat loss of a building is due to air leaking into and out of the windows and doors and other gaps in the building fabric. In areas of high exposure, it is natural that a building will use more energy to maintain the same internal conditions. Similarly, a well-sheltered building should use less. To account for this, an exposure factor is used in a similar manner to the weather correction factor.

HOW TO CALCULATE ENERGY PERFORMANCE OF BUILDINGS

Table 2.2 shows factors which should be multiplied by the space-heating energy.

Exposure factors	
Description of location	**Factor**
Sheltered The building is in a built-up area with other buildings of a similar height or greater surrounding it	1.1
Normal The building is on level ground in urban or rural surroundings. It would be usual to have some trees or adjacent buildings	1.0
Exposed Coastal and hilly sites with little or no adjacent screening	0.9

Table 2.2 Exposure correction factors

At the completion of this stage the space-heating energy is said to be 'normalised'.

NOTE:
The benchmarks produced in this publication assume that heating equipment within buildings is capable of maintaining a normal operating temperature and that such a condition prevailed during the period for which energy consumption was measured.

Step 6

Add non-space-heating energy use

All of the non-space-heating energy should now be added. It is not necessary to adjust non-space-heating energy usage because it is not significantly dependent on weather or exposure.

Step 7

Occupancy correction

The benchmarks for each category have been determined on a standard number of hours of use of the building per week or per year. If these hours vary, then a correction factor must be applied both to the fossil-fuel and electricity consumption. The basis of operating hours is different for each category and is specified under each building type.

Step 8

Determine floor area

Floor area is defined as:

- **Gross internal area** – total building measured inside external walls
- **Treated floor area** – gross areas, less plant room and other areas not directly heated (eg stores, covered car parking and roof spaces).

In multiple-storey buildings, areas are floor areas for each floor.

Step 9

Calculate performance indicators

Performance indicators for fossil fuel and electricity can now be calculated.

$$\text{Fossil-fuel performance indicator} = \frac{\text{Corrected annual fossil-fuel consumption}}{\text{Treated floor area}} = \text{......... kWh/m}^2\text{/annum}$$

$$\text{Electricity performance indicator} = \frac{\text{Corrected annual electricity consumption}}{\text{Treated floor area}} = \text{......... kWh/m}^2\text{/annum}$$

These performance indicators can then be compared with MoD benchmarks for the relevant building category.

Worked examples of this methodology are shown for each of the different building types in sections 3 to 12.

OFFICES 3

Introduction

A variety of office facilities can be found on most MoD sites, ranging from converted country houses to purpose-built annexes.

The benchmark figures (shown in table 3.1) for fossil fuel and electricity are based on good practice data of submetered office facilities in a range of MoD sites.

Definition of categories

Three different categories of office facilities are included.

Category 1
Naturally ventilated cellular – basic facilities, often relatively small, and sometimes in converted residential accommodation.

Category 2
Naturally ventilated open plan – large open plan, but with some cellular offices and special areas.

Category 3
Natural/forced ventilated – naturally ventilated, but with some forced ventilation and some comfort cooling.

Factors affecting consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Hours of occupation**
  The benchmarks assume a normal single shift, working five days per week. Typical occupation hours: 2600 hours per annum. For buildings with continuous working, the following correction factor should be applied.

Occupancy period	Correction factor
Single shift (10 hours/day) five days/week	1.0
Continuous working	0.8

Benchmarks (kWh/m^2/annum)			
Category	Fossil fuel	Electricity	Total
Category 1	110	31	141
Category 2	95	54	149
Category 3	143	60	203

Table 3.1 Benchmarks for offices

Typical energy end-use (%)	Category 1	Category 2	Category 3
Fossil fuel			
Space heating	67	58	54
Hot water/catering	7	6	6
Electricity			
Cooling	Nil	1	2
Fans, pumps, controls	3	3	10
Lighting	11	16	13
Office equipment	8	12	10
Catering	2	2	3
Other electricity use	2	2	2
Total	100	100	100

Table 3.2 Examples of typical energy end-use in offices

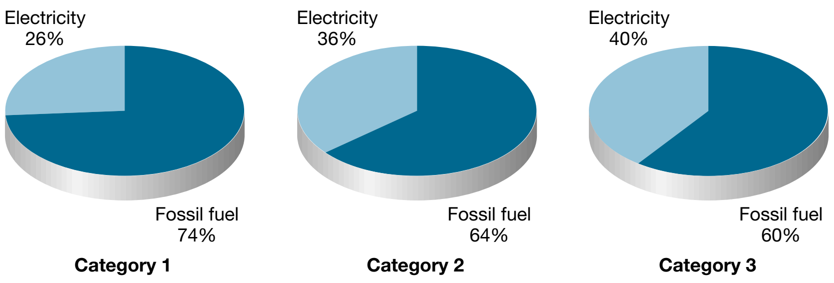


Figure 3.1 Breakdown of energy consumption by category

OFFICES

Worked example

Site location:	Southern
Degree days:	2125
Site exposure:	Sheltered
Type of facility:	Naturally ventilated cellular
Facility floor area:	1250 m^2
Hours of use:	0800-1800 weekdays
Annual electricity consumption:	42 300 kWh/annum
Metered hot water supply:	141 056 kWh/annum

Light-shaded steps are not applicable

Step 1

Step 2

Fossil-fuel performance

The heat meter reading needs to be divided by 0.76 to obtain an equivalent fossil-fuel consumption (see step 2 in section 2)

Adjusted fossil-fuel consumption $= \frac{141\ 056}{0.76} =$ 185 600 kWh/annum

Step 3

The space-heating element of this consumption must be estimated so that degree day and site exposure factors can be applied. Table 3.2 shows that, for Category 1, space heating is typically 67% and hot water/catering is 7% of total, respectively.

Therefore, space-heating element is $\frac{67 \times 185\ 600}{74} =$ 168 043 kWh/annum

and water-heating element is $\frac{7 \times 185\ 600}{74} =$ 17 557 kWh/annum

Step 4

The degree day factor is $\frac{2462}{2125} = 1.159$

Step 5

The site is sheltered, so assume a factor of 1.1 for exposure (see table 2.2 in section 2).

Apply these factors to space-heating element of fossil-fuel consumption

$168\ 043 \times 1.159 \times 1.1 =$ 214 238 kWh/annum

Step 6

Therefore normalised fossil-fuel consumption = 214 238 + 17 557 = 231 795 kWh/annum

Step 7

No correction factor is required for hours of occupation.

Step 8

Floor area = 1250 m^2

Step 9

Fossil-fuel performance $= \frac{231\ 795}{1250} =$ 185 kWh/m^2/annum

Electricity performance

Electricity consumption = 42 300 kWh/annum

No correction factor is required for hours of occupation.

Electricity performance $= \frac{42\ 300}{1250} =$ 33.8 kWh/m^2/annum

Compare actual with benchmark performance, as shown in table 3.3

OFFICES

	Actual performance ($kWh/m^2/annum$)	Benchmark performance ($kWh/m^2/annum$) (see table 3.1)	Comments
Electricity	33.8	31	Performance just above benchmark. Small savings are available (see table 3.4)
Fossil fuel	185	110	Scope for 40% fossil fuel savings to achieve benchmark. Investigate no-cost and investment measures (see table 3.4)

Table 3.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total use	–
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
Improved wall and roof insulation	Up to 30%	1 to 4
Draughtstripping	Up to 15%	1 to 2
Occupancy control on lights	3 to 10%	2 to 4

Table 3.4 Typical energy efficiency measures in offices

FOR FURTHER INFORMATION

Energy Consumption Guides

19 Energy use in offices

Good Practice Guides

16 Guide for installers of condensing boilers in commercial buildings
71 Selecting air conditioning systems. A guide for building clients and their advisors
118 Managing energy use. Minimising running costs in office equipment and related air-conditioning
160 Electric lighting controls – a guide for designers, installers and users
276 Managing for a better environment. Minimising running costs and impact of office equipment

SPORTS AND RECREATIONAL FACILITIES 4

Introduction

There are many different types of sports facilities in MoD sites. These have been broken down into the four most common categories which are defined below.

Benchmark figures for fossil fuel and electricity in a range of sports centres are based on good practice data of submetered facilities.

Definition of categories

Category 1

Dry sports facility: small – small dry sports facilities, eg multi-gyms or pavilions with shower facilities.

Category 2

Dry sports facility (without pool): large – predominantly dry sports facilities. Some wet facilities (eg sauna/showers) but no swimming areas.

Category 3

Sports facility with a pool – predominantly dry and wet sports facilities in a single location served by common plant rooms. Usually at least one pool and one sports hall.

Category 4

Swimming pool only – predominantly wet sports facilities. Some dry sports facilities, such as multi-gyms, may be provided but no sports hall.

Factors affecting consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Hours of use**
  The benchmark figures are based on 4800 hours of use per year. Variations in annual fuel use due to this factor are likely to be ±10%.

Benchmarks (kWh/m^2/annum)			
Category	Fossil fuel	Electricity	Total
Category 1	133	27	160
Category 2	250	79	329
Category 3	360	150	510
Category 4	775	165	940

Table 4.1 Benchmarks for sports and recreational facilities

Typical energy end-use (%)				
	Category 1	Category 2	Category 3	Category 4
Fossil fuel				
Space heating	67	64	52	53
Water heating	5	3	29	25
Electricity				
Fans and pumps	7	13	12	10
Lighting	19	16	4	6.5
General power	2	4	3	5.5
Total	100	100	100	100

Table 4.2 Example of typical energy end-use in sports centres

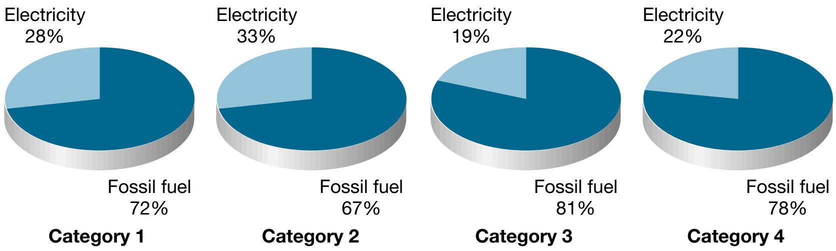


Figure 4.1 Breakdown of energy consumption by category

- **Pool temperature**
  Benchmarks are calculated on the assumption that pools are maintained at the recommended temperature of 28°C. Pool energy costs will increase or decrease by 5% for every 1°C change in temperature. Special pools (eg hydrotherapy or chilled pools for special forces training) are not included in these benchmarks.

SPORTS AND RECREATIONAL FACILITIES

Worked example

Site location:	NE Scotland
Degree days:	2810
Site exposure:	Normal/exposed
Type of facility:	Sports facility with pool
Facility floor area:	1500 m²
Hours of use:	4800 hours/annum
Annual electricity consumption:	240 000 kWh/annum
Annual gas consumption:	960 000 kWh/annum

Light-shaded steps are not applicable

Step 1

Step 2

Gas performance

Step 3

The space-heating element of gas consumption must be estimated so that degree day and site exposure factors can be applied.

Table 4.2 shows that for Category 3, space heating is typically 52% of total and water heating 29% of total.

Therefore, space-heating element is $\frac{52 \times 960\,000 \text{ kWh}}{81}$ = 616 296 kWh/annum

and water-heating element is $\frac{29 \times 960\,000 \text{ kWh}}{81}$ = 343 704 kWh/annum

Step 4

The degree day factor is $\frac{2462}{2810}$ = 0.876

Step 5

The site is normal to exposed, so assume a factor of 0.95 (see table 2.2 in section 2).
Apply factors to space-heating element of gas consumption

$616\,296 \times 0.876 \times 0.95 = 512\,882$ kWh/annum

Step 6

Therefore, normalised gas consumption = 512 882 + 343 704 = 856 586 kWh/annum

Step 7

No correction is required for hours of use.

Step 8

Floor area = 1500 m²

Step 9

Gas performance = $\frac{856\,586}{1500}$ = 571 kWh/m²/annum

Electricity performance

Electricity consumption = 240 000 kWh/annum

No correction is required for hours of use.

Electricity performance = $\frac{240\,000}{1500}$ = 160 kWh/m²/annum

Compare actual with benchmark performance, as shown in table 4.3

SPORTS AND RECREATIONAL FACILITIES

	Actual performance (kWh/m²/annum)	Benchmark performance (kWh/m²/annum) (see table 3.1)	Comments
Electricity	160	150	Performance last year just above benchmark. Maintain good operational practice. No investment
Gas	571	360	Scope for 37% gas savings to achieve benchmark. Investigate no-cost and investment measures immediately (see table 4.4)

Table 4.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total use	–
Combined heat and power (CHP)	Up to 25% of energy costs (pools)	3 to 5
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
High-efficiency motors	3 to 6% compared to standard motors	0.5 to 2 (overcost)
Variable speed drives	Up to 20% of pool electricity use	0.5 to 5
Pool covers	Up to 20% of total facilities use (includes savings on heating and ventilation costs)	1.5 to 3
Heat recovery	Up to 30% of heating requirement, if used with pool ventilation system	3 to 5

Table 4.4 Typical energy efficiency measures for sports facilities

FOR FURTHER INFORMATION

Good Practice Case Studies

43 Energy efficiency in sports and recreation buildings: condensing gas boilers
76 Energy efficiency in sports and recreation buildings: swimming pool covers

Good Practice Guides

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130 Good housekeeping in swimming pools – a guide for centre managers
137 Energy efficiency in sports and recreation buildings: effective plant maintenance
144 Energy efficiency in sports and recreation buildings – technology overview
146 Energy efficiency in sports and recreation buildings: managing energy

Sports Council Guidance Notes. Swimming Pools – Building Services

5 MULTI OCCUPANCY ACCOMMODATION

Introduction

There is a variety of different types of accommodation blocks in the MoD – depending on the service, the site and whether the accommodation is for officers, NCOs or other ranks.

In army 'Sandhurst' blocks there is usually a catering area integral to the building. For the purposes of the benchmarks it is assumed that there is no catering and, if present, this area should be excluded when calculating benchmark performance. The catering element can be added separately and this is covered in section 12.

Benchmark figures for fossil fuel and electricity are based on good practice data of submetered accommodation blocks in a range of MoD sites.

Definition of building category

The buildings in this category would have the typical characteristics:

- standalone multi-accommodation block with individual rooms
- wet central heating system
- provision of washing machines/drying areas
- small kitchen for tea-making
- no central catering.

Factors affecting consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Hours of occupancy**
  The benchmark figures are based on normal occupancy hours of 1700 to 0800.
- **Annual occupancy periods**
  The benchmark figures assume full occupancy throughout the year. An allowance should be made for periods of non-occupancy (eg during exercises or tours of duty). If the building is unoccupied during the heating season, the space-heating energy consumption will be 30% of normal to maintain an internal temperature of 10°C.
- **Catering**
  The benchmark figures assume no catering takes place. If catering is integral to an accommodation block the area should be treated separately (see section 12).

	Benchmarks kWh/m²/annum		
	Fossil fuel	Electricity	Total
Multi occupancy accommodation	225	29	254

Table 5.1 Benchmarks for multi occupancy accommodation

	Typical energy end-use (%)
Fossil fuel	
Space heating	55
Hot water	24
Electricity	
Lighting	10
Other	11
Total	100

Table 5.2 Examples of typical energy end-use in multi occupancy accommodation

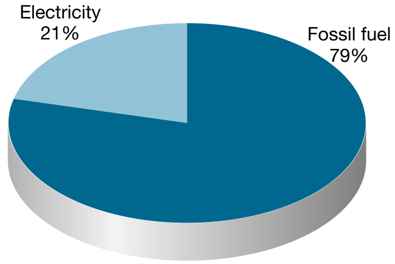

Figure 5.1 Breakdown of energy consumption

MULTI OCCUPANCY ACCOMMODATION

Worked example

Site location:	Severn Valley
Degree days:	1982
Site exposure:	Normal
Type of facility:	'Sandhurst' accommodation block with catering
Floor area:	5850 m^2 (excluding catering/dining areas)
Hours of occupation:	1700 to 0800
Annual occupancy:	Vacated mid-November to mid-February
Annual electricity consumption:	95 550 kWh/annum (excluding catering)
Annual gas consumption:	964 600 kWh/annum (excluding catering)

Light-shaded steps are not applicable

Step 1

Step 2

Step 3

Gas performance

The space-heating element of gas consumption must be estimated so that degree day and site exposure factors can be applied. Table 5.2 shows that space heating is typically 55% of total and water heating 24% of total.

Therefore, space-heating element is $\frac{55 \times 964\,600 \text{ kWh}}{79} = 671\,557$ kWh/annum

and water-heating element is $\frac{24 \text{ x } 964\,600 \text{ kWh}}{79} = 293\,043$ kWh/annum

Step 4

The degree day factor is $\frac{2462}{1982} = 1.242$

Step 5

The site is normal, so exposure factor 1.0 is applied (see table 2.2 in section 2).
Apply degree day and site exposure factors to space-heating element of gas consumption:

$671\,557 \times 1.242 \times 1.0 = 834\,074$ kWh/annum

Step 6 & 7

However, the block is unoccupied for three months during the heating season. Therefore, the space-heating, hot water and electricity consumption figures need to be adjusted upwards to estimate how much energy the block would have used if it had been occupied all year – so that a same-basis comparison can be made with the benchmarks.

Space-heating adjusted figures assume space heating is on for approximately eight months of the year. However, for three months during the space-heating season the building is unoccupied. During non-occupation the space heating is at 30% of normal to maintain a minimum temperature of 10°C. Recent trends of gas consumption indicate that a 30% reduction during the unoccupied period would mean gas consumption for the year would be 78% of all-year occupancy consumption. So the factor to apply is:

$$\frac{1}{0.78} = 1.282$$

Adjusted space heating = $834\,074 \times 1.282$ kWh/annum = 1 069 283 kWh/annum

This figure describes how much space-heating energy the building would have used if the building had been occupied all year.

MULTI OCCUPANCY ACCOMMODATION

Water-heating benchmarks assume hot water use all year. But if the building is unoccupied for three months it can be assumed to be using 75% of all-year occupancy consumption.

So the factor to apply is: $\frac{1}{0.75} = 1.333$

Adjusted water heating = 293 043 × 1.333 = 390 626 kWh/annum

This figure describes how much water-heating energy the building would have used if the building had been occupied all year.

Therefore, total adjusted gas consumption = 1 069 283 + 390 626 = 1 459 909 kWh/annum

Floor area = 5850 m^2

Step 8

Gas performance = $\frac{1\ 459\ 909}{5850}$ = 250 kWh/m^2/annum

Step 9

Electricity performance

Electricity consumption = 95 550 kWh/annum

Applying the same occupancy factor as used for water heating

Adjusted electricity consumption = 95 550 × 1.333 = 127 368 kWh/annum

Floor area = 5850 m^2

Electricity performance = $\frac{127\ 368}{5850}$ = 21.8 kWh/m^2/annum

Compare actual with benchmark performance, as shown in table 5.3

MULTI OCCUPANCY ACCOMMODATION

	Actual performance ($kWh/m^2/annum$)	Benchmark performance ($kWh/m^2/annum$) (see table 3.1)	Comments
Electricity	21.8	29	Maintain good operational practice
Gas	250	225	Scope for 10% gas savings to achieve benchmark (see table 5.4). Check for any overheating during non-occupancy period

Table 5.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total use	–
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
Improved wall and roof insulation	Up to 30%	1 to 4
Draughtstripping	Up to 15%	1 to 2
Occupancy control on lights	3 to 10%	1 to 2

Table 5.4 Typical energy efficiency measures for multi occupancy accommodation

FOR FURTHER INFORMATION

Good Practice Guides

132 Heating controls in small commercial and multi-residential buildings
189 Energy efficiency in hotels. A guide to cost-effective lighting
192 Designing energy-efficient multi-residential buildings

Good Practice Case Studies

79 Energy efficiency in large residential buildings: condensing gas boilers
245 Energy efficiency in hotels – energy efficient space heating and hot water

Introduction to Energy Efficiency

9 Hotels

WORKSHOPS 6

Introduction

On most MoD sites there are workshops for a wide range of maintenance activities. Benchmark figures for fossil fuel and electricity are based on good practice data of submetered workshop facilities in a range of MoD sites.

Definition of building category

These workshops would have typical characteristics:

- 4-5 m clear internal height with areas for storage and office space
- largely naturally ventilated, with occasional local extraction
- warm-air or radiant heater units with heating to 16-18°C plus frost protection
- lighting generally to 300 lux by fluorescent or low-bay high-pressure sodium fittings
- average 10% roof lights
- single shift, five-day week operation.

Factors affecting consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Building dimensions**
  Space heating energy consumption increases in direct proportion to ceiling height, with two exceptions:
  – where hot air accumulates at high level
  – where radiant systems are used. Sometimes the greater volume and height may reduce the need for mechanical ventilation.
- **Equipment use**
  In many workshops electricity usage for equipment is relatively low. However, in heavily used engineering workshops equipment such as lathes, cranes, hoists and compressed air can use 20% to 30% of total consumption for that building. The proportion depends on the type of installed equipment and hours of use. It is also important to consider the effect of local extract ventilation (eg for welding).
- **Hours of occupation**
  In buildings with high ventilation requirements, heating energy use is almost directly proportional to hours of use. However, in well-insulated and heavyweight buildings, much of the heating energy is used in raising them to the necessary temperature – not in maintaining temperature.
  The benchmarks in table 6.1 apply in workshops with a single shift, five-day working week. For buildings with a double shift or continuous working, the following correction factors should be applied for fossil fuel consumption.

Benchmarks (kWh/m²/annum)			
	Fossil fuel	Electricity	Total
Workshops	175	29	204

Table 6.1 Benchmarks for workshops

Typical energy end-use (%)	
Fossil fuel	
Space heating	75
Hot water	3
Electricity	
Fans, pumps, controls	3
Lighting	10
Other	9
Total	100

Table 6.2 Examples of typical energy end-use in workshops

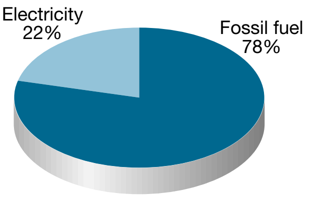

Figure 6.1 Breakdown of energy consumption

Occupancy period	Correction factor
Single shift, 5-day week	1.00
Single shift, 7-day week	0.93
Double shift, 5-day week	0.77
Double shift, 7-day week	0.72
Continuous working	0.72

Any occupation factor required for electricity consumption is calculated on an 'hours occupied' basis, as shown in the worked example.

Single shift corresponds to an occupancy of about 10 hours per day: double shift corresponds to an occupancy of at least 15 hours per day.

WORKSHOPS

Worked example

Site location:	South West
Degree days:	1850
Site exposure:	Sheltered
Type of facility:	Workshop
Floor area:	964 m^2
Hours of use:	Single shift, 7-day week
Annual electricity consumption:	46 300 kWh/annum
Annual gas consumption:	164 400 kWh/annum

Light-shaded steps are not applicable

Step 1

Step 2

Gas performance

Step 3

The space-heating element of gas consumption must be estimated so that degree day and site exposure factors can be applied. Gas consumption in July (when no gas is used for space heating) indicates that 96% of gas is used for space heating and 4% is for water heating over one year.

Therefore, space-heating element is $164\,400 \times 0.96 = 157\,824$ kWh/annum

and water-heating element is $164\,400 \times 0.04 = 6576$ kWh/annum

Step 4

The degree day factor is $\frac{2462}{1850} = 1.331$

Step 5

The site is sheltered, so assume an exposure factor of 1.1. (see table 2.2 in section 2).

Apply factors to space-heating element of gas consumption
$157\,824 \times 1.331 \times 1.1 = 231\,070$ kWh/annum

Step 6

Therefore, normalised gas consumption $= 231\,070 + 6576 = 237\,646$ kWh/annum

Step 7

Now apply occupation correction factor of 0.93 to gas consumption $237\,646 \times 0.93 = 221\,011$ kWh/annum

Step 8

Floor area = 964 m^2

Step 9

Gas performance $= \frac{221\,011}{964} = 229$ kWh/m^2/annum

Electricity performance

Electricity consumption = 46 300 kWh/annum

Occupancy is single shift, 7-day week, ie 10 hours/day × 7 = 70 hours/week
Benchmarks are based on single shift, 5-day week, ie 10 hours/day × 5 = 50 hours/week
Therefore, occupation factor $= \frac{50}{70} = 0.71$

Apply occupation correction factor of 0.71

Electricity consumption corrected $= 46\,300 \times 0.71 = 32\,873$ kWh/annum

Electricity performance $= \frac{32\,873}{964} = 34.1$ kWh/m^2/annum

Compare actual with benchmark performance, as shown in table 6.3

WORKSHOPS

	Actual performance (kWh/m²/annum)	Benchmark performance (kWh/m²/annum) (see table 6.1)	Comments
Electricity	34.1	29	Performance 18% above benchmark. Check equipment hours of use and extract ventilation
Gas	229	175	Scope for 24% gas savings to achieve benchmark. Check boiler controls, building fabric and local extract ventilation (see table 6.4)

Table 6.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total use	–
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
High-efficiency motors (overcost)	3 to 6% compared to standard motors	0.5 to 2
Improved wall and roof insulation	Up to 20%	2 to 4
High-speed shutter doors	Up to 18%	2 to 3
Destratification fans	Up to 25%	1 to 2

Table 6.4 Typical energy efficiency measures for workshops

FOR FURTHER INFORMATION

Energy Consumption Guides

18 Energy efficiency in industrial buildings and sites

Fuel Efficiency Booklets

3 Economic use of fired space heaters for industry and commerce
16 Economic thickness of insulation for existing industrial buildings

Good Practice Case Studies

120 Energy efficiency in refurbishment of industrial buildings. John Brown Engineering Ltd
295 Energy efficiency in refurbishment of industrial buildings. J W Arrowsmith Ltd
309 Energy efficient lighting in industrial buildings. T I Apollo Ltd

Good Practice Guides

158 Energy efficiency in lighting for industrial buildings – a guide for building managers

7 MOTOR TRANSPORT FACILITIES

Introduction

In most MoD sites there are motor transport facilities for storage of transport vehicles and for simple maintenance procedures. Major maintenance would normally take place in workshops (see section 6).

Benchmark figures for fossil fuel and electricity are based on good practice data of submetered motor transport facilities in a range of MoD sites.

Definition of building category

These facilities would have typical characteristics:

- 5-6 m clear internal height to accommodate a variety of motor vehicles
- some storage and office facilities
- door openings along one side of building for vehicle access
- wall-mounted extractor fans
- high-bay fluorescent lighting with local task lighting
- warm-air or radiant heater units maintaining a temperature of 16-18°C plus frost protection
- single shift, five-day week operation.

Factors affecting consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Building dimensions**
  Space-heating energy consumption increases in direct proportion to ceiling height, with two exceptions:
  – where hot air accumulates at high level
  – where radiant systems are used.
  Sometimes the greater volume and height may reduce the need for mechanical ventilation.
- **Equipment use**
  In motor transport facilities, electricity usage is relatively low for equipment use. However, it is important to identify larger users of air compressors and hours of use.
- **Hours of occupation**
  The benchmarks in table 7.1 apply to motor transport facilities with a single shift, five-day working week. For buildings with a double shift or continuous working, the following correction factors should be applied for fossil fuel consumption.

Benchmarks (kWh/m²/annum)			
	Fossil fuel	Electricity	Total
Motor transport facilities	317	20	337

Table 7.1 Benchmarks for motor transport facilities

Typical energy end-use (%)	
Fossil fuel	
Space heating	81
Water heating	2
Electricity	
Fans, pumps, controls	3
Lighting	10
Other	4
Total	100

Table 7.2 Examples of typical energy end-use in motor transport facilities

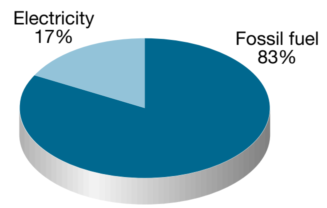

Figure 7.1 Breakdown of energy consumption

Occupancy period	Correction factor
Single shift, 5-day week	1.00
Single shift, 7-day week	0.93
Double shift, 5-day week	0.77
Double shift, 7-day week	0.72
Continuous working	0.72

Any occupation factor required for electricity consumption is calculated on an ‘hours occupied’ basis, as shown in the worked example.

Single shift corresponds to an occupancy of about 10 hours per day; double shift corresponds to an occupancy of at least 15 hours per day.

MOTOR TRANSPORT FACILITIES

Worked example

Site location:	North Eastern
Degree days:	2550
Site exposure:	Exposed
Type of facility:	Motor transport facilities
Floor area:	2372 m²
Hours of use:	Double shift, seven-day week
Annual electricity consumption:	81 256 kWh/annum
Metered hot water:	834 816 kWh/annum

Light-shaded steps are not applicable

Step 1

Fossil-fuel performance

Step 2

The heat meter reading needs to be divided by 0.76 to obtain an equivalent fossil-fuel consumption (see step 2 in section 2).

Adjusted fossil-fuel consumption $= \frac{834\ 816}{0.76} =$ 1 098 442 kWh/annum

Step 3

The space-heating element of this consumption must be estimated so that degree day and site exposure factors can be applied. Table 7.2 shows that space heating is typically 81% of total consumption and hot water 2%.

Therefore, space-heating element is $\frac{81 \times 1\ 098\ 442}{83} =$ 1 071 974 kWh/annum

and water-heating element is $\frac{2 \times 1\ 098\ 442}{83} =$ 26 468 kWh/annum

Step 4

The degree day factor is $\frac{2462}{2550} = 0.965$

Step 5

The site is exposed, so an exposure factor of 0.9 is applied (see table 2.2 in section 2).
Apply factors to space-heating element of fossil-fuel consumption:

$1\ 071\ 974 \times 0.965 \times 0.9 =$ 931 009 kWh/annum

Step 6

Therefore, normalised fossil-fuel consumption = 931 009 + 26 468 = 957 477 kWh/annum

Step 7

Now apply occupation correction factor of 0.72 to fossil-fuel consumption: $957\ 477 \times 0.72 =$ 689 383 kWh/annum

Step 8

Floor area = 2372 m²

Step 9

Fossil-fuel performance $= \frac{689\ 383}{2372} =$ 291 kWh/m²/annum

Electricity performance

Electricity consumption = 81 256 kWh/annum

Occupancy is double shift, 7-day week, ie 15 hours/day × 7 = 105 hours/week
Benchmarks are based on single shift, 5-day week, ie 10 hours/day × 5 = 50 hours/week
Therefore, occupation factor $= \frac{50}{105} = 0.48$

Apply occupation correction factor of 0.48

Electricity consumption corrected = 81 256 × 0.48 = 39 003 kWh/annum

Electricity performance $= \frac{39\ 003}{2372} =$ 16.4 kWh/m²/annum

Compare actual with benchmark performance, as shown in table 7.3

MOTOR TRANSPORT FACILITIES

	Actual performance (kWh/m²/annum)	Benchmark performance (kWh/m²/annum) (see table 7.1)	Comments
Electricity	16.4	20	Performance is below benchmark. Maintain good operational practice
Fossil fuel	291	317	Performance is below benchmark. Maintain good operational practice

Table 7.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total use	–
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
High-efficiency motors	3 to 6% compared to standard motors	0.5 to 2 (overcost)
Improved wall and roof insulation	Up to 20%	2 to 4
High-speed shutter doors	Up to 18%	2 to 3
Destratification fans	Up to 25%	1 to 2

Table 7.4 Typical energy efficiency measures for motor transport facilities

FOR FURTHER INFORMATION

Energy Consumption Guides

18 Energy efficiency in industrial buildings and sites

Fuel Efficiency Booklets

3 Economic use of fired space heaters for industry and commerce

16 Economic thickness of insulation for existing industrial buildings

Good Practice Case Studies

272 Energy efficiency in refurbishment of industrial buildings. Dunlop Ltd

294 Energy efficiency in refurbishment of industrial buildings. Oxford Automotive Components

Good Practice Guides

158 Energy efficiency in lighting for industrial buildings - a guide for building managers

8 STORES/WAREHOUSES

Introduction

There are a variety of stores and warehouses on MoD sites, ranging from converted hangars to ammunition stores requiring specific levels of temperature and humidity. Energy consumption usually varies with occupation. Therefore two categories are used: occupied and unoccupied.

Benchmark figures for fossil fuel and electricity are based on good practice data of submetered stores/warehouses in a range of MoD sites.

Definition of building category

The building type in this category has the typical characteristics:

- 4-10 m in height
- natural ventilation
- heating is by warm-air or radiant heating
- occupied stores heated to 15°C
- unoccupied stores at 5°C to 10°C
- occupied stores partially to fully lit
- unoccupied stores only lit for access.

For automatically accessed stores, electricity consumption will increase significantly because of mechanical handling equipment. These stores have not been included in the benchmarks in table 8.1.

Factors affecting consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Building dimensions**
  Space heating energy consumption increases in direct proportion to ceiling height, with two exceptions:
  – where hot air accumulates at high level
  – where radiant systems are used.
- **Hours of occupation**
  The benchmarks for Category 1, occupied stores in table 8.1 apply in stores/warehouses with a single shift, five-day week. For buildings with double shift or continuous working, the following correction factors should be applied.

Benchmarks (kWh/m²/annum)			
Category	**Fossil fuel**	**Electricity**	**Total**
Category 1 Occupied	187	34	221
Category 2 Unoccupied	54	3	57

Table 8.1 Benchmarks for stores/warehouses

Typical energy end-use (%)		
	Category 1	**Category 2**
Fossil fuel		
Space heating	90	91
Water heating	1	Nil
Electricity		
Lighting	6	4
General power	3	5
Total	100	100

Table 8.2 Example of typical energy end-use in stores/warehouses

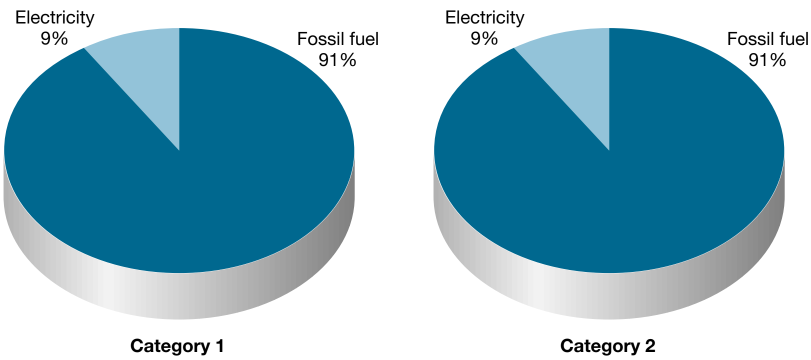

Figure 8.1 Breakdown of energy consumption by category

Occupancy period	Correction factor
Single shift, 5-day week	1.00
Single shift, 7-day week	0.83
Double shift, 5-day week	0.77
Double shift, 7-day week	0.72
Continuous working	0.72

Single shift corresponds to an occupancy of about 10 hours per day; double shift corresponds to an occupancy of at least 15 hours per day.

STORES/WAREHOUSES

Worked example

Site location:	Northern Ireland
Degree days:	2481
Site exposure:	Normal
Type of facility:	Unoccupied warehouse
Floor area:	920 m^2
Hours of use:	Unoccupied, but frost protection needed
Annual electricity consumption:	3772 kWh/annum
Annual oil consumption:	4997 litres gas oil/annum

Light-shaded steps are not applicable

Step 1

Oil performance

Step 2

Converting litres to kWh: 4997 × 10.6 = 52 968 kWh/annum (see table 2.1 in section 2)

Step 3

All the oil is used for space heating.

Step 4

The degree day factor is $\frac{2462}{2481}$ = 0.992

Step 5

Step 6

The site has normal exposure, so assume a factor of 1.0 (see table 2.2 in section 2). Apply factors to oil consumption

52 968 × 0.992 × 1.0 = 52 544 kWh/annum

Step 7

No correction factor is needed for hours of occupation.

Step 8

Floor area = 920 m^2

Step 9

Oil performance = $\frac{52\ 544}{920}$ = 57 kWh/m^2/annum

Electricity performance

Electricity consumption = 3772 kWh/annum

No correction factor is needed for hours of occupation.

Electricity performance = $\frac{3772}{920}$ = 4.1 kWh/m^2/annum

Compare actual with benchmark performance, as shown in table 8.3

STORES/WAREHOUSES

	Actual performance (kWh/m²/annum)	Benchmark performance (kWh/m²/annum) (see table 7.1)	Comments
Electricity	4.1	3	Small savings available (see table 8.4)
Oil	57	54	Small savings available (see table 8.4)

Table 8.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total use	–
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
Improved wall and roof insulation	Up to 30%	1 to 4
Destratification fans	Up to 25%	1 to 2
Occupancy control on lights	3 to 10%	2 to 4

Table 8.4 Typical energy efficiency measures for stores/warehouses

FOR FURTHER INFORMATION

Energy Consumption Guides

18 Energy efficiency in industrial buildings and sites

Fuel Efficiency Booklets

3 Economic use of fired space heaters for industry and commerce

16 Economic thickness of insulation for existing industrial buildings

Good Practice Case Studies

102 Lighting controls in industrial stores. Heavy stores building, Powergen, Fiddlers Ferry Power Station

103 Energy efficient lighting in low ceiling industrial stores. Lighting stores building, Powergen, Fiddlers Ferry Power Station

175 Energy efficiency in refurbishment of industrial buildings. Parts Warehouse

Introduction to Energy Efficiency

13 Factories and warehouses

HANGARS 9

Introduction

There is a wide range of hangar types used in the MoD, and they are used for a number of tasks including storage and maintenance. Energy consumption varies considerably and is dependent on hangar use, building fabric and location.

Hangar types have been divided into five main categories which are defined below.

Benchmark figures for fossil fuel and electricity are based on good practice data of submetered facilities for each category in a range of MoD sites.

Definition of categories

Five different categories of hangars are included.

Category 1
Heated and uninsulated

Category 2
Low heating and uninsulated

Category 3
Heated, insulated and refurbished

Category 4
Very low heating or store with low activity

Category 5
Unheated

Typical features of hangers in Categories 1 to 4 are:

- 10-14 m in height
- natural ventilation, heating to 16°C during working hours with some areas with specific humidity control levels
- heating by warm-air or radiant heaters
- lighting generally to 150 lux by high-pressure sodium high-bay fittings with localised lighting for specific tasks
- average 10% rooflights.

Benchmarks (kWh/m²/annum)			
Category	Fossil fuel	Electricity	Total
Category 1	444	21	465
Category 2	315	12	327
Category 3	220	23	243
Category 4	100	9	109
Category 5	Nil	9	9

Table 9.1 Benchmarks for hangars

Typical energy end-use (%)	
	Category 3
Fossil fuel	
Space heating	90
Water heating	1
Electricity	
Fans, pumps, controls	2
Lighting	5
Other	2
Total	100

Table 9.2 Example of typical energy end-use in a Category 3 hangar

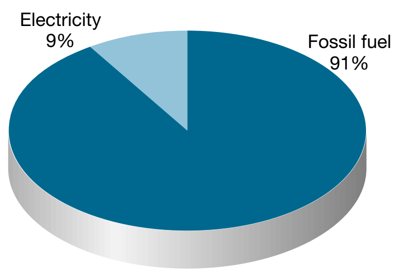

Figure 9.1 Breakdown of energy use in a Category 3 hangar

The benchmarks in this section relate to hangars that are of the traditional or RAF type of large hangar, and which were primarily designed for use by fixed-wing aircraft. The name 'hangar' is now also being applied to a range of modern, purpose-built structures intended for other uses including tank hangar, maintenance hangar or helicopter hangar. This new generation of hangar is usually less than 10 m in height. Depending on the use of the facility, it may be more appropriate to use the benchmarks given in sections 6, 7 or 8 of this Guide. If in doubt, seek expert guidance.

HANGARS

Factors influencing consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Building dimensions**
  Space-heating energy consumption increases in direct proportion to internal building height, with two exceptions:
  – where hot air accumulates at high level
  – where radiant systems are used.
- **Hours of occupation**
  In Category 1 and 2 hangars, the benchmarks assume heating is geared to a single shift (minimum of 10 hours per day), five days per week. Energy consumption would vary directly in proportion to the hours of occupation because these hangars are uninsulated (see below). Category 3 benchmarks apply to hangars working a single shift (minimum of 10 hours per day), five days per week. For double shift or continuous working for Categories 1, 2 and 3 the following correction factors would apply.

Occupancy period	Correction factor
Single shift 5-day week	1.00
Single shift 7-day week	0.83
Double shift, 5-day week	0.77
Double shift, 7-day week	0.72
Continuous working	0.72

  Category 4 benchmarks assume little and intermittent occupancy and heating is mainly for frost protection. No occupancy factor is required. Category 5 benchmarks assume no occupancy and no heating either because there is no heating system or material stored does not require frost protection. Some electricity might be used for intermittent visits.
  No occupancy factor is required.
- **Humidity control**
  In hangars requiring controlled humidity levels, electricity consumption will increase but will be offset by lower heating requirements if radiant heating is provided for occupants in specific areas.
- **Equipment use**
  Engineering and maintenance equipment and compressed air can add up to 30% of total energy use in a hangar. The proportion depends on the type of installed equipment and hours of use.

Worked example

Site location:	North East
Degree days:	2553
Site exposure:	Exposed
Type of facility:	Category 2, low heated, partially insulated, some dehumidification
Floor area:	12 500 m²
Hours of use:	Single shift, five-day week
Annual electricity consumption:	480 000 kWh/annum
Annual gas consumption:	3 750 000 kWh/annum

Light-shaded steps are not applicable

Step 1

Step 2

Gas performance

Step 3

The space-heating element of gas consumption must be estimated so that degree day and site exposure factors can be applied. An estimate of overall energy consumption indicated that fossil fuel is 91%, comprising 90% for space heating and 1% for hot water. Separating the two elements gives:

Space-heating element is $\dfrac{90 \times 3\ 750\ 000 \text{ kWh}}{91} = 3\ 708\ 790$ kWh/annum

and water-heating element is $\dfrac{1 \times 3\ 750\ 000 \text{ kWh}}{91} = 41\ 209$ kWh/annum

Step 4

The degree day factor is $\dfrac{2462}{2553} = 0.964$

Step 5

The site is exposed, so assume a full exposure factor of 0.9 (see table 2.2 in section 2).

Apply factors to space-heating element of gas consumption

$3\ 708\ 790 \times 0.964 \times 0.9 = 3\ 217\ 746$ kWh/annum

Step 6

Therefore normalised gas consumption = 3 217 746 + 41 209 = 3 258 955 kWh/annum

Step 7

No correction factor is needed for hours of occupation.

Step 8

Floor area = 12 500 m²

Step 9

Gas performance = $\dfrac{3\ 258\ 955}{12\ 500} = 261$ kWh/m²/annum

Electricity performance

Electricity consumption = 480 000 kWh/annum

No correction factor is needed for hours of occupation.

Electricity performance = $\dfrac{480\ 000}{12\ 500} = 38.4$ kWh/m²/annum

Comparing actual with benchmark performance, as shown in table 9.3

HANGARS

	Actual performance (kWh/m²/annum)	Benchmark performance (kWh/m²/annum) (see table 9.1)	Comments
Electricity	38.4	12	Electricity consumption is excessive compared to benchmark. Carry out audit of electricity use. Focus on electricity use for dehumidification as one possible reason
Gas	261	315	Performance last year better than benchmark but up on the previous year. Monitor gas consumption monthly and maintain good operational practice

Table 9.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total use	–
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
High-efficiency motors	3 to 6% compared to standard motors	0.5 to 2 (overcost)
Improved wall and roof insulation	Up to 50%	1 to 4
Microswitches on hangar doors to control heating	Up to 10%	3 to 5
Occupancy control on lights	3 to 10%	2 to 4
Destratification fans	Up to 25%	1 to 2

Table 9.4 Typical energy efficiency measures for hangars

FOR FURTHER INFORMATION

Energy Consumption Guides

18 Energy efficiency in industrial buildings and sites

Fuel Efficiency Booklets

3 Economic use of fired space heaters for industry and commerce
16 Economic thickness of insulation for existing industrial buildings

Good Practice Guides

158 Energy efficient lighting for industrial buildings – a guide for building managers

MESSES WITH INTEGRAL ACCOMMODATION

10

Introduction

This category would be typically officers' messes with catering and dining facilities, common rooms, lounges, bars and accommodation. Many facilities are converted country houses with more recently built accommodation annexes.

The benchmarks assume small amounts of catering for residents and some lunchtime meals. For messes with large catering facilities, treat as a separate category – see section 12.

Benchmark figures for fossil fuel and electricity are based on good practice data of submetered facilities in a range of MoD sites.

Factors affecting consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Hours of occupation**
  The benchmark figures are based on normal occupancy hours of 1700 to 0900, with some occupancy at lunchtime for meals and meetings during the day.
- **Annual occupancy periods**
  The benchmark figures assume 70% to 100% occupancy throughout the year.

Benchmarks (kWh/m²/annum)			
	Fossil fuel	Electricity	Total
Messes with integral accommodation	235	75	310

Table 10.1 Benchmarks for messes with integral accommodation

Typical energy end-use (%)	
Fossil fuel	
Space heating	52
Water heating	22
Electricity	
Heating/hot water	3
Lighting	9
Other, including ventilation	14
Total	100

Table 10.2 Examples of typical energy end-use in messes with integral accommodation

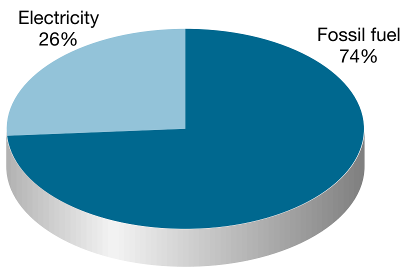

Figure 9.1 Breakdown of energy consumption

MESSES WITH INTEGRAL ACCOMMODATION

Worked example

Site location:	Wales
Degree days:	2496
Site exposure:	Semi-exposed
Type of facility:	Officers' mess
Floor area:	2750 m^2
Hours of use:	1700 to 0900
Annual occupancy:	All year
Catering:	Meals for up to 15 residents (typically) with lunches for people attending training courses
Annual electricity consumption:	241 900 kWh/annum
Annual gas consumption:	764 200 kWh/annum

Light-shaded steps are not applicable

Step 1

Step 2

Gas performance

Step 3

The space-heating element of gas consumption must be estimated so that degree day and exposure factors can be applied. Table 10.2 shows that space heating is typically 52% and water heating is 22% of total, respectively.

Therefore, space-heating element is $\frac{52 \times 764\,200}{74} = 537\,005$ kWh/annum

and water-heating element is $\frac{22 \times 764\,200}{74} = 227\,195$ kWh/annum

Step 4

The degree day factor is $\frac{2462}{2496} = 0.986$

Step 5

The site is semi-exposed, so assume a factor of 0.95 for exposure (see table 2.2 in section 2). Apply factors to space-heating element of gas consumption

$537\,005 \times 0.986 \times 0.95 = 503\,013$ kWh/annum

Step 6

Therefore normalised gas consumption = 503 013 + 227 195 = 730 208 kWh/annum

Step 7

No correction is required for hours of occupation.

Step 8

Floor area = 2750 m^2

Step 9

Gas performance $= \frac{730\,208}{2750} = 266$ kWh/m^2/annum

Electricity performance

Electricity consumption = 241 900 kWh/annum

No correction is required for hours of occupation.

Electricity performance $= \frac{241\,900}{2750} = 88$ kWh/m^2/annum

Compare actual with benchmark performance, as shown in table 10.3

MESSES WITH INTEGRAL ACCOMMODATION

	Actual performance ($kWh/m^2/annum$)	Benchmark performance ($kWh/m^2/annum$) (see table 10.1)	Comments
Electricity	88	75	Scope for 15% savings to achieve benchmark. Consider lighting controls and end-user awareness
Gas	266	235	Scope for 12% savings to achieve benchmark. Fit TRVs at correct settings in unoccupied bedrooms

Table 10.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total	–
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
Improved wall and roof insulation	Up to 30%	1 to 4
Draughtstripping	Up to 15%	1 to 2
Occupancy control on lights	3 to 10%	1 to 2
Zone heating system controls	Up to 10%	3 to 5
Upgrade insulation on hot water tanks and pipes	Up to 3%	2 to 3
Install showers and flow restrictors on hot water taps	Up to 4%	1 to 2

Table 10.4 Typical energy efficiency measures in messes with integral accommodation

FOR FURTHER INFORMATION

Energy Consumption Guides

36 Energy efficiency in hotels – a guide for owners and managers

Good Practice Case Studies

41 Energy efficiency in hotels: condensing gas boilers

243 Energy efficiency in hotels – energy efficient lighting. Forte Crest Hotels, Brighouse, West Yorkshire

245 Energy efficiency in hotels – energy efficient space heating and hot water. Ritz Hotel, Piccadilly, London

Good Practice Guides

189 Energy efficiency in hotels. A guide to cost-effective lighting

Introduction to Energy Efficiency

9 Hotels

TRAINING AND EDUCATION FACILITIES 11

Introduction

There are three main categories of training and education facilities on MoD sites. These categories are defined below.

Benchmark figures for fossil fuel and electricity are based on good practice data of submetered facilities in a range of training and educational facilities on MoD sites.

Definition of categories

Three categories are included.

Category 1

Naturally ventilated lecture rooms – these are typically naturally ventilated lecture rooms with: white/blackboard; overhead projector and video facilities; some office accommodation; a library; a lounge and small kitchen.

Category 2

Forced ventilated lecture rooms – these are typically forced ventilated lecture rooms with audio-visual facilities. The lecture rooms are usually heated by a conventional wet heating system with radiators controlled by TRVs. Ventilation is usually operating under time control or presence detectors (which monitor CO_2 levels). There is some office accommodation, a library, lounge and small kitchen.

Category 3

Technology training facilities – these typically have: mechanical or electronic demonstration equipment and computers with some mechanical ventilation; some office accommodation; a library; lounge and small kitchen.

Factors affecting consumption

- **Weather**
  A weather correction factor will need to be applied. This methodology is described fully in section 2.
- **Exposure**
  A site exposure correction factor will need to be applied. This methodology is described fully in section 2.
- **Hours of occupation**
  These benchmark figures are based on normal occupancy of 0800 to 1700 on weekdays only.
- **Special energy use**
  The benchmark figures do not include special energy use within training facilities, eg flight simulators (see section 13).

Benchmarks kWh/m²/annum			
Category	**Fossil fuel**	**Electricity**	**Total**
Category 1	114	15	129
Category 2	334	88	422
Category 3	123	36	159

Table 11.1 Benchmarks for training and education facilities

Typical energy end-use (%)			
	Category 1	**Category 2**	**Category 3**
Fossil fuel			
Space heating	75	74	63
Water heating	5	6	4
Electricity			
Fans/pumps	4	15	6
Lighting	6	3	12
General power	10	2	15
Total	100	100	100

Table 11.2 Example of typical energy end-use in training and education facilities

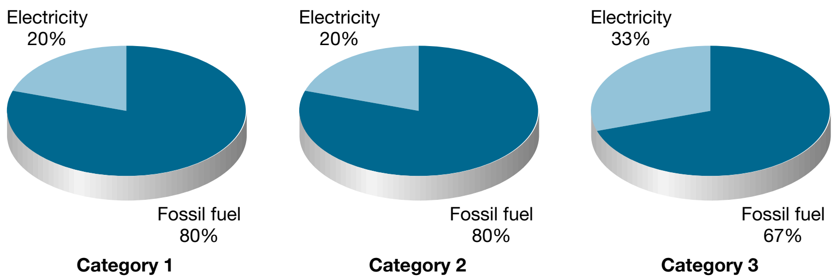

Figure 11.1 Breakdown of fuel consumption by category

TRAINING AND EDUCATION FACILITIES

Worked example

Site location:	Thames Valley
Degree days:	2025
Site exposure:	Sheltered
Type of facility:	Training block – naturally ventilated
Floor area:	2620 m^2
Hours of use:	0800-1700 weekdays
Annual electricity consumption:	49 600 kWh/annum
Annual gas consumption:	298 680 kWh/annum

Light-shaded steps are not applicable

Step 1

Step 2

Gas performance

Step 3

The space-heating element of gas consumption must be estimated so that degree day and exposure factors can be applied. An examination of gas consumption through the year indicates that 7% of consumption is used for water heating and 93% for space heating.

Therefore, space-heating element is $\frac{93 \times 298\,680}{100} = 277\,772$ kWh/annum

and water-heating element is $\frac{7 \times 298\,680}{100} = 20\,908$ kWh/annum

Step 4

The degree day factor is $\frac{2462}{2025} = 1.216$

Step 5

The site is sheltered, so assume a factor of 1.1 for exposure (see table 2.2 in section 2). Apply factors to space-heating element of gas consumption

$277\,772 \times 1.216 \times 1.1 = 371\,548$ kWh/annum

Step 6

Therefore normalised gas consumption = 371 548 + 20 908 = 392 456 kWh/annum

Step 7

No correction is required for hours of occupation.

Step 8

Floor area = 2620 m^2

Step 9

Gas performance $= \frac{392\,456}{2620} = 150$ kWh/m^2/annum

Electricity performance

Electricity consumption = 49 600 kWh/annum

No correction is required for hours of occupation.

Electricity performance $= \frac{49\,600}{2620} = 18.9$ kWh/m^2/annum

Compare actual with benchmark performance, as shown in table 11.3

TRAINING AND EDUCATION FACILITIES

	Actual performance (kWh/m²/annum)	Benchmark performance (kWh/m²/annum) (see table 11.1)	Comments
Electricity	18.9	15	Scope to save 21% to achieve benchmark. Examine lighting controls and check hot water immersion heaters. Raise awareness of end-users
Gas	150	114	Scope for 24% savings – check boiler controls, insulation and draughtstripping

Table 11.3 Comparing actual with benchmark performance

Measure	Savings in energy cost	Payback (years)
Good housekeeping, monitoring and targeting	5 to 15% of total	–
Condensing boilers	15 to 20% compared to new standard boilers	2 to 3 (overcost)
High-efficiency boilers	5 to 7% compared to new standard boilers	2 to 3 (overcost)
High-efficiency lighting	Up to 75% for specific lamp types	1 to 15
Improved wall and roof insulation	Up to 30%	1 to 4
Draughtstripping	Up to 15%	1 to 2
Upgrade insulation on hot water tanks and pipes	Up to 3%	2 to 3
Occupancy control on lights	3 to 10%	1 to 2

Table 11.4 Typical energy efficiency measures in training and education facilities

FOR FURTHER INFORMATION

Energy Consumption Guides

54 Energy efficiency in further and higher education

Good Practice Case Studies

150 Energy management, Manchester University

333 Energy management practices in further education, Southwark College of Further Education – a low-cost pragmatic approach

334 The benefits of including energy efficiency early in the design stage – Anglia Polytechnic University

335 Investment in energy efficiency at the University of Warwick

CATERING FACILITIES 12

Introduction

Catering facilities vary widely in MoD sites – some have all-electric kitchens; others use liquefied petroleum gas (LPG) but the preferred fuel mix is natural gas and electricity.

Four different types of facility are described. Benchmark figures for fossil fuel and electricity are based on good practice data of submetered facilities for each category in a range of MoD sites.

Definition of categories

Four different categories of catering facilities are included.

Category 1
Officers' mess – typically serving 50 to 150 meals per day; kitchen and dining facilities integrated into an officers' mess.

Category 2
Sergeants' mess – typically serving 100 to 200 meals per day; kitchen and dining facilities integrated into a sergeants' mess.

Category 3
Officers'/sergeants' combined mess – typically, officers' and sergeants' messes are served by a common kitchen (but each with separate dining areas), usually serving 100 to 200 meals per day.

Category 4
Junior ranks' mess
Typically a stand-alone catering block complete with kitchens and dining facilities serving between 500 and 2500 meals per day.

The facilities in each of these categories would include:

- **food storage areas** including walk-in cold rooms, refrigeration areas, food storage and delivery areas
- **food preparation areas** prior to cooking or serving
- **cooking areas** with fully equipped catering equipment including mechanical extraction
- **serving areas** – usually cafeteria-style for larger numbers
- **dining areas**
- **washing-up areas** equipped with automatic dishwashing machines and sink areas.

The benchmarks assume the following.

- Fuel supply is gas/electricity.
- Energy is used in food storage, preparation, cooking, serving, dining and washing-up. It is important to check that any submetering is measuring consumption to all the above areas before using the benchmarks. For example, some submeters may only measure food storage, preparation and cooking but exclude lighting, heating, ventilation, dishwashing and hot water supplies.

The benchmark used is kWh/meal. This is used in preference to kWh/m^2/annum because energy use should relate directly to the number of meals served.

For all-electric kitchens, the fossil fuel and electricity benchmarks should be combined to form a single benchmark.

Benchmarks (kWh/meal)			
Category	Fossil fuel	Electricity	Total
Category 1	4.4	2.5	6.9
Category 2	3.9	2.2	6.1
Category 3	3.6	2.1	5.7
Category 4	2.5	1.4	3.9

Table 12.1 Benchmarks for catering facilities

Typical energy end-use (%)	
Area	Category 4
Food storage preparation and cooking	41
Hot water and dishwashing	20
Heating, ventilation in kitchen and dining areas	28
Lighting in kitchen and dining areas	11
Total	100

Table 12.2 Examples of typical energy end-use in catering facilities

CATERING FACILITIES

Factors affecting consumption

- Energy consumption per meal decreases as the number of meals per day increases. This is particularly true up to 700 meals per day. This effect becomes reduced in the range of 700 to 1000 meals per day. Above 1000 meals per day the effect becomes negligible.
- The matching of installed equipment capacity to design throughput has an impact on energy consumption per meal. The closer the match, the greater the energy efficiency.
- The degree of weekend usage plays an important part in energy performance.
- Most of the energy used in catering is not weather-related or exposure-related except the space heating in dining areas. Therefore, performance is not normalised as in other building categories.

Table 12.2 shows typical energy end-use for catering in Category 4 catering facilities. Most catering facilities use gas and electricity. However, some catering facilities are all electric: therefore, no breakdown is given for fossil fuel and electricity for the different types of energy use.

Worked example

Site location:	Scotland
Type of facility:	Junior ranks' mess
Service:	Approximately 2100 meals per day, including most weekends
Annual electricity consumption:	1 102 500 kWh/annum (all services)
Annual gas consumption:	2 352 000 kWh/annum (all services)

Gas performance

Number of days in service during the year = 350 days

Therefore, number of meals per year = 350 × 2100 = 735 000 meals

Gas consumption = 2 352 000 kWh/annum

$$\text{Gas performance} = \frac{2\,352\,000}{735\,000} = 3.2 \text{ kWh/meal}$$

Electricity performance

Electricity consumption = 1 102 500 kWh/annum

$$\text{Electricity performance} = \frac{1\,102\,500}{735\,000} = 1.5 \text{ kWh/meal}$$

Compare actual with benchmark performance, as shown in table 12.3

	Actual performance (kWh/meal)	Benchmark performance (kWh/meal) (see table 12.1)	Comments
Electricity	1.5	1.4	Small savings available (see table 12.4)
Gas	3.2	2.5	Scope to reduce gas consumption by 22% to achieve benchmark. Initiate a training programme for chefs, and monitor results weekly. Check maintenance schedules on gas-using equipment and check hot water controls

Table 12.3 Comparing actual with benchmark performance

CATERING FACILITIES

Area	Energy-saving measures
Food storage	Locate refrigerators and freezers away from heat sources. Minimise frequency of opening refrigerators and freezers. Never put hot food in refrigerators. Adopt a planned defrosting programme. Check door/lid seals and replace as necessary. Replace old equipment with new efficient models. Install motor controls to improve compressor efficiency at low loads.
Food cooking and serving	Minimise preheating times for ovens, fryers and other equipment. Switch off ovens before the end of the cooking time. Minimise hot storage of cooked food. Keep hot plates and gas burners clean. Introduce regular servicing of cooking appliances, including thermostats and automatic timers. Install energy-efficient and effectively controlled cooking appliances. Select induction hobs. Select equipment sizes appropriate to task. Consider batch cooking to optimise use of appliances. Install microwave ovens to cook and reheat meals.
Air extraction equipment	Install energy-efficient ventilation hoods. Locate hoods directly over ovens, fryers, and grills which need air extraction. Coordinate layout of kitchen hoods and ductwork with cooking equipment layout and the cooking process. Switch on extract systems only when required and switch off as soon as possible. Clean filters, grilles and fan blades regularly to prevent grease build-up. Close external doors when operating extract fans.
Dishwashing and hot water	Maximise dishwasher loads with full loading and correct stacking. Clean and maintain machines regularly. Consider using sanitising liquids and water softeners to reduce boost temperatures. Install efficient dishwasher units incorporating economy wash cycles and/or heat recovery. Consider direct-fired gas heaters for water supply. Undertake regular cleaning and maintenance. Insulate hot water tanks and pipework. Check hot water temperature thermostats and reduce where possible (note 55°C is minimum recommended temperature to avoid Legionnaire's disease). Install spray taps for handwashing facilities. Mend leaking taps.
Heating	Ensure kitchen extract ventilation does not draw excessive air from dining areas. Consider heat recovery system for mechanical ventilation. Improve insulation in walls and roofs. Consider double glazing. Install draught doors and windows. Fit automatic door closers. Operate kitchen extract systems only when required for cooking periods. Install local thermostatic controls, eg tamper-proof TRVs in kitchen. Do not use cooking appliances to heat kitchen areas.
Lighting	Install more efficient lighting sources. Keep lamps and luminaires clean. Switch off when not required. Fit automatic lighting controls for intermittently used areas, eg cloakrooms, stores.

Table 12.4 Typical energy efficiency measures in catering

CATERING FACILITIES

FOR FURTHER INFORMATION

Good Practice Guides

156 Energy efficient refurbishment of public houses – catering

160 Electric lighting controls – a guide for designers, installers and users

189 Energy efficiency in hotels. A guide to cost-effective lighting

222 Reducing catering costs through energy efficiency. A guide for kitchen designers, contract caterers and operators

Introduction to Energy Efficiency

2 Catering establishments

SPECIALIST SITE FACILITIES

13

Introduction

So far, the buildings-related energy consumption of a range of buildings has been considered. But these categories do not cover all building types or represent energy use in the MoD for specialist activities. Energy used external to buildings also needs to be considered.

Key areas to consider are:

- district heating
- external/security lighting
- special or 'process' energy use.

District heating and benchmarks

Benchmarks concern individual building performance and are calculated from the energy actually entering the building. Therefore, if a building is heated from an external source (eg district heating) the heat losses from the mains supplying the building should not be included in assessing the building's performance. They are, however, an important consideration across the site, as they can amount to 50% or more of the heat generated throughout the year.

The benchmarks assume a decentralised system (ie a boiler in each building). This means the benchmarks include losses from the boiler in heat generation (eg flue gas losses).

Therefore, if heat meters measure the supply of hot water or steam to a building (from a district heating system) it is important to divide the metered heat supply by the central boiler efficiency to obtain a figure based on primary fuel supply so that meaningful comparisons can be made between buildings. These figures also give useful information on overall site efficiency.

It is then possible to ask the questions:

- is it economic to decentralise?
- is it possible to shut down the system in summer and use local sources for domestic hot water (DHW) generation?

As a general guide, district heating should be phased out unless a financially viable combined heat and power (CHP) arrangement can be retrofitted.

External/security lighting

In many MoD sites external lighting can be a large energy user. It is important to measure this load. If submetering or temporary metering is not feasible, the load can be estimated by examining the installed load and hours of annual usage. Typical usage would be 4300 hours per annum, but this figure will vary for different parts of the UK.

Special energy use

In the MoD, there is some special energy use, eg simulators, satellite/communication centres. These buildings will use their normal energy requirement plus a special or 'process' component. It is important to submeter these buildings and, if possible, also measure the process energy used. Some of this process energy may be dissipated as heat (eg special electrical equipment or compressors).

There are two ways of dealing with these special category buildings.

a) Submeter the building and establish trends. Temporary metering is another option. If possible, measure energy use with and without process energy to gauge the different component parts. Establish your own special benchmarks for your building and set realistic reduction targets.

b) Deduct process energy from total energy to establish the non-process energy use and then treat the building as a normal building to the nearest conventional building category benchmark.

Other areas to consider:

- security buildings – high energy usage due to 24-hour occupation
- medical facilities
- churches and chapels
- social facilities
- emergency services (eg Fire)
- NAAFI.

ASSESSING SITE PERFORMANCE 14

Introduction

Where submetered data is lacking, it is possible to predict overall site energy consumption using building floor areas and benchmarks, and then comparing the calculated total benchmark consumption for fossil fuel and electricity with actual overall consumption data from main meter readings. The methodology for this approach is shown in figure 14.1 with a sample calculation in section 15.

Having used the benchmarks to calculate individual building energy use, it is important to add the energy not attributed to building categories listed, eg catering, heat losses in district heating distribution systems, external lighting, special energy use (eg aircraft simulators, compressors, etc) and other energy users (eg churches).

To simplify the calculation, benchmarks from sections 3 to 11 are not adjusted to take into account local variations in degree days, site exposure, occupancy, etc. However, some adjustments can be made towards the end of the calculation, as shown in the sample calculation in section 15.

Once all the site energy data has been estimated, a benchmark comparison can be made with actual figures. This will give an overall assessment of a site and may highlight areas for further investigation to get a more detailed insight into how energy is used and the scope for savings in particular areas.

In some situations a degree of submetering exists and that clearly helps to identify buildings with the greatest potential for savings. However, where electricity submetering does not exist, it may be necessary to use portable electricity meters which are in widespread use on MoD sites. Each large site and energy manager should have access to this equipment. Where the equipment is not available it should be obtained as a matter of priority and if outright purchase is difficult, in the short term, it should be either hired or borrowed.

1. Measure the treated floor area of each building or obtain data from an asset register

↓

2. List buildings by their area in m^2 and categories

↓

3. List benchmarks for each category where appropriate

↓

4. Multiply benchmarks by areas for each category for fossil fuel and electricity

↓

5. Add in catering energy use

↓

6. Add in other energy use (eg district heating mains losses, security/car park lighting)

↓

7. Calculate benchmark energy usage for site for fossil fuel and electricity using worksheet 14.1, 14.2, 14.3 and 14.4

↓

8. Compare calculated benchmark usage against actual annual usage for fossil fuel and electricity, using worksheet 14.5

↓

9. Adjust actual usage for weather, exposure and occupancy, if necessary, to benchmark standard conditions. Complete worksheet 14.6 using the method shown on page 15-5

↓

10. Estimate the scope for savings if benchmark figures were not reached. Identify priority areas for further investigations

Figure 14.1 Methodology to assess overall site energy performance

ASSESSING SITE PERFORMANCE

Category		Fossil-fuel benchmark (kWh/m²/annum)	Treated floor area (m²)	Calculated benchmark for annual fossil-fuel usage (kWh)
Offices	Category 1	110		
	Category 2	95		
	Category 3	143		
Sports	Category 1	133		
	Category 2	250		
	Category 3	360		
	Category 4	775		
Multi occupancy accommodation		225		
Workshops		175		
Motor transport facilities		317		
Stores/ warehouses	Category 1	187		
	Category 2	54		
Hangars	Category 1	444		
	Category 2	315		
	Category 3	220		
	Category 4	100		
	Category 5	Nil		
Messes with integral accommodation		235		
Training/education facilities	Category 1	114		
	Category 2	334		
	Category 3	123		
Sub-total using benchmarks				A

Electrically heated buildings

In the case of electrically heated buildings, the fossil-fuel benchmarks shown above need to be adjusted. Typically the benchmark would need to be multiplied by 0.76 or appropriate figure to take into account that there will be no flue gas or other heat losses from boilers in an electrically heated building.

Worksheet 14.1 Calculation of buildings-based fossil-fuel benchmark consumption

ASSESSING SITE PERFORMANCE

Total A then has to be added to other fossil-fuel usage which includes the following.

1. Catering

Using kWh/meal benchmarks:

Category 1 4.4 kWh/meal
Category 2 3.9 kWh/meal
Category 3 3.6 kWh/meal
Category 4 2.5 kWh/meal

2. District heating distribution system losses

These losses must be added and can be considerable. The heat loss from district heating systems is usually directly related to the design capacity of the system so the losses are proportionately higher at low loads, eg during the mild periods during the spring and autumn.

A study of MoD district heating systems yields a rule of thumb of 40% (± 2%) for annual distribution losses for most large systems. For smaller systems (eg boiler supplying six buildings in close proximity to each other) the losses might be 25%. These figures are sufficient for estimates in this procedure.

3. Special use/other

This would be any other fossil-fuel usage not already mentioned but excluding transport. Fossil-fuel usage should be included in this section for buildings not already considered in total A of worksheet 14.1.

Building use per annum		=			[ ] (total A from worksheet 14.1)	**kWh**
Catering per annum						
Category 1	4.4 kWh/meal	×	(annual no. of meals)	=	....	kWh
Category 2	3.9 kWh/meal	×	(annual no. of meals)	=	....	kWh
Category 3	3.6 kWh/meal	×	(annual no. of meals)	=	....	kWh
Category 4	2.5 kWh/meal	×	(annual no. of meals)	=	....	kWh
District heating losses per annum						
	0.4	×	(kWh annual fossil fuel to boiler)	=	....	kWh
Special/other use per annum				=	....	kWh
Total fossil fuel benchmark per annum				=	....	**kWh**

Worksheet 14.2 Calculation of the total benchmark for fossil-fuel usage for the site

ASSESSING SITE PERFORMANCE

Category		Electricity benchmark (kWh/m²/annum)	Treated floor area (m²)	Calculated benchmark for annual electricity usage (kWh)
Offices	Category 1 Category 2 Category 3	31 54 60		
Sports	Category 1 Category 2 Category 3 Category 4	27 79 150 165		
Multi occupancy accommodation		29		
Workshops		29		
Motor transport facilities		20		
Stores/ warehouses	Category 1 Category 2	34 3		
Hangars	Category 1 Category 2 Category 3 Category 4 Category 5	21 12 23 9 9		
Messes with integral accommodation		75		
Training/education facilities	Category 1 Category 2 Category 3	15 88 36		
Sub-total using benchmarks				B

Worksheet 14.3 Calculation of buildings-based electricity benchmark consumption

ASSESSING SITE PERFORMANCE

Total B then has to be added to other electricity usage which includes the following.

1. Catering

Using kWh/meal benchmarks:

Category 1 2.5 kWh/meal

Category 2 2.2 kWh/meal

Category 3 2.1 kWh/meal

Category 4 1.4 kWh/meal

2. External/security lighting

Electricity for external purposes, security lighting for perimeter fences, car parks and street lighting must be included. The load can be estimated by examining the installed load and hours of annual usage. Typical usage would be 4300 hours per annum, but this figure will vary for different parts of the UK.

3. Special use/other

This topic is covered in section 13. Electricity usage should be included in this section for buildings not already considered in total B of worksheet 14.3.

Building use per annum		=			[ ] (total B from worksheet 14.1)	**kWh**
Catering						
Category 1	2.5 kWh/meal	×	.... (annual no. of meals)	=	....	kWh
Category 2	2.2 kWh/meal	×	.... (annual no. of meals)	=	....	kWh
Category 3	2.1 kWh/meal	×	.... (annual no. of meals)	=	....	kWh
Category 4	1.4 kWh/meal	×	.... (annual no. of meals)	=	....	kWh
External/security lighting per annum						
Installed load	....	kW ×	4300 hours	=	....	kWh
Special/other use per annum				=	....	kWh
Total electicity benchmark per annum				=	....	**kWh**

Worksheet 14.4 Calculation of the total benchmark electricity usage for the site

ASSESSING SITE PERFORMANCE

	Fossil fuel	Electricity	Total
Calculated benchmark annual consumption (kWh)			
Actual annual consumption (from meter readings) (kWh)			
Difference (kWh)			

Worksheet 14.5 Comparison between calculated benchmark consumption and actual consumption

To obtain a more accurate site assessment it is possible to adjust actual annual consumption to reflect variances in degree days, exposure and occupancy from standard conditions assumed for benchmark performance. A similar table can be redrawn this time with adjusted annual consumptions. This is illustrated in the sample calculation in section 15. By completing worksheet 14.6, the differences between 'calculated' and, 'adjusted actual' consumptions will help in highlighting where action is required.

	Fossil fuel	Electricity	Total
Calculated benchmark annual consumption (kWh)			
Adjusted actual annual consumption (see page 15-5) (kWh)			
Difference (kWh)			

Worksheet 14.6 Comparison between calculated benchmark annual consumption and adjusted actual annual consumption (which takes account of degree days, site exposure and occupancy patterns)

SAMPLE CALCULATION

15

The relevant floor areas are added so that fossil-fuel and electricity benchmark figures can be calculated. These are totalled to obtain the buildings-based fossil-fuel benchmark consumption (A) and the buildings-based electricity benchmark consumption (B). Other uses are then added to give an overall site benchmark figure. Next, these site benchmark figures can be compared with actual consumption data obtained from meter readings (worksheet 15.5). Finally, the site benchmark figures are adjusted to account for degree days, site exposure and occupancy patterns. These data are then compared with meter readings, giving a more accurate assessment of actual site performance against benchmark.

This section is a sample calculation for an MoD site using the calculation method described in section 14.

Category		Fossil-fuel benchmark (kWh/m²/annum)	Treated floor area (m²)	Calculated benchmark for annual fossil-fuel usage (kWh)
Offices	Category 1	110	960	105 600
	Category 2	95	725	68 875
	Category 3	143	560	80 080
Sports	Category 1	133	420	55 860
	Category 2	250	Nil	Nil
	Category 3	360	1720	619 200
	Category 4	775	Nil	Nil
Multi occupancy accommodation		225	9270	2 085 750
Workshops		175	1360	238 000
Motor transport facilities		317	980	310 660
Stores/ warehouses	Category 1	187	1200	224 400
	Category 2	54	720	38 880
Hangars	Category 1	444	Nil	Nil
	Category 2	315	Nil	Nil
	Category 3	220	Nil	Nil
	Category 4	100	Nil	Nil
	Category 5	Nil	Nil	Nil
Messes with integral accommodation		235	2120	498 200
Training/education facilities	Category 1	114	1850	210 900
	Category 2	334	Nil	Nil
	Category 3	123	1260	154 980
Sub-total using benchmarks				4 691 385 A

Note: Remember to multiply the benchmark figures by 0.76 or appropriate figure if the buildings are electrically heated (see worksheet 14.1).

Worksheet 15.1 Calculation of buidings-based fossil-fuel benchmark consumption

SAMPLE CALCULATION

Building use per annum		=			4 691 385	**kWh**
					(total A from worksheet 15.1)	
Catering per annum						
Category 1	4.4 kWh/meal	× 33 600	(annual no. of meals)	=	147 840	kWh
Category 2	3.9 kWh/meal	× 52 800	(annual no. of meals)	=	205 920	kWh
Category 3	3.6 kWh/meal	× 0	(annual no. of meals)	=	0	kWh
Category 4	2.5 kWh/meal	× 750 200	(annual no. of meals)	=	1 875 500	kWh
District heating losses per annum						
	0.4	× 8 216 000	(kWh annual fossil fuel to boiler)	=	3 286 400	kWh
Special/other use per annum			Medical centre	=	620 000	kWh
			Church	=	126 000	kWh
Total fossil fuel benchmark per annum				=	10 953 045	**kWh**

Worksheet 15.2 Calculation of the total benchmark for fossil-fuel usage for the site

SAMPLE CALCULATION

Category		Electricity benchmark (kWh/m²/annum)	Treated floor area (m²)	Calculated benchmark for annual electricity usage (kWh)
Offices	Category 1	31	960	29 760
	Category 2	54	725	39 150
	Category 3	60	560	33 600
Sports	Category 1	27	420	11 340
	Category 2	79	Nil	Nil
	Category 3	150	1720	258 000
	Category 4	165	Nil	Nil
Multi-occupancy accommodation		29	9270	268 830
Workshops		29	1360	39 440
Motor transport facilities		20	980	19 600
Stores/ warehouses	Category 1	34	1200	40 800
	Category 2	3	720	2160
Hangars	Category 1	21	Nil	Nil
	Category 2	12	Nil	Nil
	Category 3	23	Nil	Nil
	Category 4	9	Nil	Nil
	Category 5	9	Nil	Nil
Messes with integral accommodation		75	2120	159 000
Training/education facilities	Category 1	15	1850	27 750
	Category 2	88	Nil	Nil
	Category 3	36	1260	45 360
Sub-total using benchmarks				974 790 B

Worksheet 15.3 Calculation of buildings-based electricity benchmark consumption

SAMPLE CALCULATION

Building use per annum		=		974 790			**kWh**
				(total B from worksheet 14.1)			
Catering							
Category 1	2.5 kWh/meal	×	33 600	(annual no. of meals)	=	84 000	kWh
Category 2	2.2 kWh/meal	×	52 800	(annual no. of meals)	=	116 160	kWh
Category 3	2.1 kWh/meal	×	0	(annual no. of meals)	=	0	kWh
Category 4	1.4 kWh/meal	×	750 200	(annual no. of meals)	=	1 050 280	kWh
External/security lighting per annum							
Installed load	136	kW ×	4300 hours		=	584 800	kWh
Special/other use per annum				Medical centre	=	206 600	kWh
				Church	=	37 800	kWh
				Compressor	=	92 500	kWh
				Machine 'x'	=	87 000	kWh
Total electicity benchmark per annum					=	3 233 930	**kWh**

Worksheet 15.4 Calculation of the total benchmark electricity usage for the site

	Fossil fuel	Electricity	Total
Calculated benchmark annual consumption (kWh)	10 953 045	3 233 930	14 186 975
Actual annual consumption (from meter readings) (kWh)	13 650 720	4 029 341	17 680 061
Difference (kWh)	2 697 675 (19.8%)	795 411 (19.7%)	3 493 086 (19.8%)

Worksheet 15.5 Comparison between calculated benchmark consumption and actual consumption

SAMPLE CALCULATION

ANALYSIS AND ACTION

Fossil-fuel consumption

As shown in worksheet 15.5, the actual fossil-fuel consumption is 19.8% higher than the calculated benchmark amount. The calculated method includes use of the benchmarks which assume standard degree days, normal site exposure and certain occupancy criteria. The site in question is semi-exposed and the annual degree days are 2563. Therefore, the space-heating element of actual fossil-fuel consumption should be adjusted by two factors:

degree day factor $\frac{2462}{2563} = 0.96$

exposure factor = 0.95 (see table 2.2 in section 2)

The calculated benchmark fossil-fuel consumption shows that consumption in buildings is approximately 50% of total usage (worksheet 15.2). The other 50% is accounted for by the catering and district heating losses.

Assuming this 50/50 split also applies to the actual situation (worksheet 15.5): **buildings element** of actual fossil-fuel consumption: **13 650 720** × 0.5 = **6 825 360** kWh/annum

Also assuming that 80% is used for space heating, and 20% is used for water heating: **space-heating** element is: **6 825 360** × 0.8 = **5 460 288** kWh/annum

Then apply the degree day and exposure adjustment factors: **5 460 288** × 0.96 × 0.95 = **4 979 782** kWh/annum

Therefore the adjustment to space heating for weather and exposure should reduce consumption by:
5 460 288 – 4 979 782 = 480 506 kWh/annum

Therefore, adjusted actual consumption would be approximately:
13 650 720 – 480 506 = **13 170 214** kWh/annum

This is still **13 170 214** – **10 953 045** = **2 217 169** kWh/annum more than calculated benchmark consumption (see worksheet 15.6) ie scope for reduction of 16.8%.

Some of this extra usage could be accounted for by occupancy hours greater than those used for the benchmarks in this Guide. A check of occupancy hours on the site showed that some buildings operated above and others below the levels specified for the benchmarks. These effectively cancelled each other out and therefore no adjustment is made.

It is likely that the savings will be achieved by the largest users and this is where the benchmarks help to give a composite picture. The most likely areas for savings will be:

- main boiler plant serving the district heating system (eg boiler efficiency, etc.)
- district heating distribution system (eg insulation, leaks, rationalising pipework, etc)
- large occupied buildings
- offices
- wet sports centre
- multi occupancy accommodation
- workshops
- messes with integral accommodation
- junior ranks' catering mess.

Monitoring and investigation should take place which should highlight no-cost, low-cost and high-cost measures with paybacks.

SAMPLE CALCULATION

Electricity consumption

The actual electricity consumption is 19.7% higher than the calculated amount using benchmarks (see worksheet 15.6). The weather and exposure factors would not alter electricity consumption significantly.

Again, it is likely that the largest savings will come from the larger users such as:

- large occupied buildings
- wet sports centre
- multi occupancy accommodation
- messes with integral accommodation
- junior ranks' catering mess
- compressor.

Again monitoring and detailed investigations should follow.

In summary, with adjusted actual fossil-fuel consumption figures the table becomes as shown in worksheet 15.6

	Fossil fuel	Electricity	Total
Calculated benchmark annual consumption (kWh)	10 953 045	3 233 930	14 186 975
Adjusted actual annual consumption (kWh)	13 170 214	4 029 341	17 199 555
Difference (kWh)	2 217 169 (16.8%)	795 411 (19.7%)	3 012 580 (17.5%)

Worksheet 15.6 Comparison between calculated benchmark annual consumption and adjusted actual annual consumption (which takes account of degree days, site exposure and occupancy patterns)

ENERGY-SAVING MEASURES

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The following measures are classified by payback period and can be considered as a means of reducing consumption to achieve benchmark figures.

No-cost/low-cost measures

- Eliminate unnecessary running of boiler plant at periods of low or no occupancy, and summer months.
- Rationalise the use of accommodation blocks so that buildings can be isolated or heated to frost protection levels only.
- Reduce the use of supplementary electric heaters.
- Ensure that frost thermostats are correctly set.
- Check that controls are set to provide the correct temperatures at the required time.
- Check that time switches, programmers, optimum start controls and weather compensation controls are set up and operating correctly.
- Establish a system to check control settings, especially when they may have been overridden in response to unexpected circumstances.
- Review hot-water thermostat accuracy and temperature settings periodically, but take precautions to avoid the risk of legionnaires' disease.
- Isolate immersion heaters during the summer, and install time controls.
- Isolate parts of systems not in use, eg seasonally. Remove redundant pipework where possible.
- Ensure plant and equipment is regularly and correctly maintained.
- Use swimming pool covers where fitted.
- Replace 38 mm fluorescent tubes with high-efficiency 26 mm tubes as the former expire (if switch-start fittings are in place).
- Switch off lights and other equipment when not required. Label light switches.
- Maximise the use of daylight. Clean light fittings and improve reflection of light from walls and ceilings by using pale colours.
- Set illumination levels to the type of activity. Reduce lighting levels where possible and remove surplus lamps – but without compromising safety or security.
- Ensure equipment is used appropriately, eg don't use hobs or ovens for space heating.
- Raise end-users awareness of how they can help improve efficiency.

Short payback measures (less than two years)

- Recommission boiler/heating controls.
- Check boiler efficiency periodically and make improvements.
- Fit boiler sequence controls.
- Repair leaks on distribution mains.
- Install, repair or replace thermostats.
- Insulate domestic hot water cylinders.
- Provide additional heating controls for individual heaters.
- Re-set hot water thermostat and time switches and make tamper-proof.
- Blank off unused air grilles behind radiators.
- Seal unused chimneys and ventilation stacks.

  } Check ventilation requirement of any installed gas appliances.
- Fit reflective foil behind radiators on external walls.
- Install time switches for swimming pool circulation pumps.
- Install heating controls to hangar doors.
- Replace tungsten lighting with compact fluorescent lamps.

ENERGY-SAVING MEASURES

- Fit draughtstripping to external doors and windows.
- Install shower and tap restrictors.
- Install time switches, dimmers, photocells and sensors so lighting operates only when required, to correct levels.

Medium payback measures (two to five years)

- Install instruments to control boiler burners and measure flue gas composition.
- Improve/repair thermal insulation on boilers.
- Install or extend a building energy management system.
- Install dual fuel burners to larger boiler plant.
- Insulate pipework, valves and flange covers.
- Replace central hot water boiler with point-of-use gas or off-peak electric heaters.
- Fit thermostatic radiator valves.
- Fit time switches to fan convector heaters.
- Install manual swimming pool covers.
- Fit automatic door closers.
- Improve insulation in loft areas.
- Install cavity wall insulation.
- Install spray taps (soft water areas only).
- Fit automatic valves to showers.
- Install heat recovery systems in swimming pools.
- Control run times for extraction fans.
- Rearrange switching of light fittings.
- Improve zoning of heating system.
- Install condensing boilers.
- Replace electric water heaters with gas-fired versions.
- Install occupancy controls to lighting.
- Replace old fluorescent fittings with high-frequency fluorescents.
- Install energy-efficient appliances when refurbishing catering areas.
- Purchase energy efficient office equipment, eg PCs, copiers, printers, etc.

APPENDIX 1 – DEGREE DAYS

During the heating season in the UK, the weather conditions vary from day to day and from month to month. This results in a variable heating load from year to year. The heat required to maintain an internal temperature, at say 19°C, is dependent on the difference between the inside and outside temperatures.

One way to account for of this variable space-heating requirement is the use of degree days. Degree days are the daily difference in temperature between a base temperature and the 24-hour mean outside temperature when the base temperature is higher than the maximum daily temperature.

The base temperature, t_b, is defined as the outside temperature above which no space heating is required. The value normally adopted for the UK is 15.5°C. It is assumed that internal heat gains from, for example, people, lighting, electrical equipment and solar gains) are sufficient to maintain a comfortable internal temperature at an outside temperature of 15.5°C without the use of space heating. However, if the outside temperature falls below 15.5°C then space heating is required. (For healthcare buildings in the UK a higher base temperature of 18.5°C is chosen because a higher internal temperature must be maintained.)

The 24-hour mean outside temperature is taken to be the average between the maximum and minimum outside temperature. Hence the number of degree days in a day is:

$$t_b - {}^1/_2\,(t_{max} + t_{min})$$

Therefore for

$t_{max} = 11°C$

and

$t_{min} = 1°C$

in one day,

number of degree days

$= 15.5 - {}^1/_2\,(11 + 1)$

$= 9.5$ degree days

The number of degree days in a month are usually added together and compared with the energy consumed for space heating. The relationship is usually linear, and variations from this line can give warning of a particular problem which may otherwise go unnoticed, eg boilers losing heat because they are not isolated, badly maintained burners or badly adjusted dampers.

The number of degree days over a year can vary considerably, eg in NE Scotland there are typically 2810 degree days compared to 1898 in Devon/Cornwall. It is for this reason that it is important to adjust energy consumption to a 20-year average degree day standard of 2462 degree days so that proper like-for-like comparisons are made. This standard is the basis of the benchmark performance figures in this Guide.

Cooling degree days can also be used to examine the performance of refrigeration plant providing summer cooling or other duties.

For a full explanation of degree days obtain a copy of Fuel Efficiency Booklet 7 ‘Degree days’ from BRECSU or ETSU whose details are shown on the back cover of this publication.

APPENDIX 2 – FURTHER INFORMATION

MoD technical publications
The following publications are listed in the Defence Estates 'Technical Publications Index' available from the Stationery Office.

TB 10/93
Design energy targets
DEO (W)/DEO, June 1993

TB 58/94
Utilities – sub-metering of new and refurbished accommodation for monitoring and targeting
DEO (W)/DEO, December 1994

TB 95/05
Energy Conservation – the Boiler (Efficiency) Regulations 1993
DEO (W)/DEO, February 1995

TB 96/12
Policy and practice for the management of non operational energy in the Ministry of Defence
DEO (W)/DEO, June 1996
Notes Mandatory: supersedes Chapter 8 of JSP 418

TB 97/49
Energy efficiency advice term consultants
DEO/DEO, November 1997
Supersedes TB15/93

HBF 11.03
Energy Saving
DEO/DEO, February 1998

MEEG 2/16
Energy Conservation
PSA/DEO, January 1988

MEEG 5/16
Energy Conservation
PSA/DEO, November 1984

TGCE 9
Water and energy conservation in sanitary installations
PSA/DEO, March 1997

Building for Energy Efficiency – The Clients' briefing guide
CIC/CIC, March 1997
ISBN 1 898 671095

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APPENDIX 3 – SUMMARY OF MoD ENERGY BENCHMARKS

	Category	Fossil-fuel benchmark (kWh/m²/annum)	Electricity benchmark (kWh/m²/annum)	Total benchmark (kWh/m²/annum)
Offices	1	110	31	141
	2	95	54	149
	3	143	60	203
Sports and recreational facilities	1	133	27	160
	2	250	79	329
	3	360	150	510
	4	775	165	940
Multi occupancy accommodation		225	29	254
Workshops		175	29	204
Motor transport facilities		317	20	337
Stores/warehouses	1	187	34	221
	2	54	3	57
Hangars	1	444	21	465
	2	315	12	327
	3	220	23	243
	4	100	9	109
	5	0	9	9
Messes with integral accommodation		235	75	310
Training/education facilities	1	114	15	129
	2	334	88	422
	3	123	36	159

Table A3.1 Benchmarks for MoD establishments

Benchmarks (kWh/meal)			
Category	Fossil fuel	Electricity	Total
Category 1	4.4	2.5	6.9
Category 2	3.9	2.2	6.1
Category 3	3.6	2.1	5.7
Category 4	2.5	1.4	3.9

Table A3.2 Benchmarks for catering facilities

APPENDIX 3 – SUMMARY OF MoD ENERGY BENCHMARKS

	Category	Fossil-fuel benchmark (kWh/m²/annum)	Electricity benchmark (kWh/m²/annum)	Total benchmark (kWh/m²/annum)
Offices	1	110	31	141
	2	95	54	149
	3	143	60	203
Sports and recreational facilities	1	133	27	160
	2	250	79	329
	3	360	150	510
	4	775	165	940
Multi occupancy accommodation		225	29	254
Workshops		175	29	204
Motor transport facilities		317	20	337
Stores/warehouses	1	187	34	221
	2	54	3	57
Hangars	1	444	21	465
	2	315	12	327
	3	220	23	243
	4	100	9	109
	5	0	9	9
Messes with integral accommodation		235	75	310
Training/education facilities	1	114	15	129
	2	334	88	422
	3	123	36	159

Table A3.1 Benchmarks for MoD establishments

Benchmarks (kWh/meal)			
Category	Fossil fuel	Electricity	Total
Category 1	4.4	2.5	6.9
Category 2	3.9	2.2	6.1
Category 3	3.6	2.1	5.7
Category 4	2.5	1.4	3.9

Table A3.2 Benchmarks for catering facilities

The Department of the Environment, Transport and the Regions' Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

For further information on:

Buildings-related projects contact:
Enquiries Bureau

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Industrial projects contact:
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E-mail etsuenq@aeat.co.uk

Internet **BRECSU** – http://www.bre.co.uk/brecsu/
Internet **ETSU** – http://www.etsu.com/eebpp/home.htm

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting etc.